NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

COST BENEFIT ANALYSIS OF A UTILITY SCALE WASTE-TO-ENERGY/CONCENTRATING SOLAR POWER HYBRID FACILITY AT FORT BLISS

by

Tommy J. Clement

June 2012

Thesis Advisor:	Daniel Nussbaum
Second Reader:	Eva Regnier

Approved for public release; distribution is unlimited

THIS PAGE INTENTIONALLY LEFT BLANK

REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** June 2012	**3. REPORT TYPE AND DATES COVERED** Master's Thesis

4. TITLE AND SUBTITLE Cost Benefit Analysis of a Utility Scale Waste-to-Energy/Concentrating Solar Power Hybrid Facility at Fort Bliss	**5. FUNDING NUMBERS**
6. AUTHOR(S) Tommy J. Clement	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A	**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number ______N/A______.

12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited	**12b. DISTRIBUTION CODE** A

13. ABSTRACT (maximum 200 words)

The Cost Benefit Analysis of a Waste to Energy (WtE)/Concentrating Solar Power (CSP) Hybrid Facility located on Fort Bliss is a comprehensive analysis of the costs and benefits of a WtE/CSP facility to the Army. Since no capital or operating costs are required from the Army, the increased cost of electricity becomes the overarching cost. This thesis attempts to monetize the benefits of energy security, environmental impact, meeting legislative mandates, and meeting Net Zero Energy goals. Both Congressional legislation and Executive orders dictate the increased consumption and production of renewable energy by federal agencies. WtE/CSP presents a strategy toward achieving these mandates, and Fort Bliss is well located to capitalize on this strategy. This thesis estimates those costs and benefits based on available data. Those estimates are discounted for time and adjusted for inflation. The thesis then conducts sensitivity analysis around potential variations in the data to explore changes to the monetized values.

14. SUBJECT TERMS Waste to Energy, Renewable Energy, Cost Benefit Analysis	**15. NUMBER OF PAGES** 67
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

THIS PAGE INTENTIONALLY LEFT BLANK

Approved for public release; distribution is unlimited

COST BENEFIT ANALYSIS OF A UTILITY SCALE WASTE-TO-ENERGY/CONCENTRATING SOLAR POWER HYBRID FACILITY AT FORT BLISS

Tommy J. Clement
Major, United States Army
B.S., United States Military Academy, 1997

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
June 2012

Author: Tommy J. Clement

Approved by: Daniel R. Nussbaum
Thesis Advisor

Eva Regnier
Second Reader

Robert F. Dell
Chair, Department of Operations Research

THIS PAGE INTENTIONALLY LEFT BLANK

ABSTRACT

The Cost Benefit Analysis of a Waste to Energy (WtE)/Concentrating Solar Power (CSP) Hybrid Facility located on Fort Bliss is a comprehensive analysis of the costs and benefits of a WtE/CSP facility to the Army. Since no capital or operating costs are required from the Army, the increased cost of electricity becomes the overarching cost. This thesis attempts to monetize the benefits of energy security, environmental impact, meeting legislative mandates, and meeting Net Zero Energy goals. Both Congressional legislation and Executive orders dictate the increased consumption and production of renewable energy by federal agencies. WtE/CSP presents a strategy toward achieving these mandates, and Fort Bliss is well located to capitalize on this strategy. This thesis estimates those costs and benefits based on available data. Those estimates are discounted for time and adjusted for inflation. The thesis then conducts sensitivity analysis around potential variations in the data to explore changes to the monetized values.

THIS PAGE INTENTIONALLY LEFT BLANK

TABLE OF CONTENTS

LIST OF FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF ACRONYMS AND ABBREVIATIONS

AIC	Akaike's Information Criterion
CA	California
CPI	Consumer Price Index
CSP	Concentrating Solar Power
DOA	Department of the Army
DOD	Department of Defense
DOE	Department of Energy
EIA	Energy Information Administration
E.O.	Executive Order
EPA	Environmental Protection Agency
EPACT	Energy Policy Act
FEMP	Federal Energy Management Program
FY	Fiscal Year
GHG	Greenhouse Gas
HAP	Hazardous Air Pollutants
IE&E	Installations, Energy and Environment
IMCOM	Installation Management Command
I&E	Installations and Environment
kWh	Kilowatt Hour
LFG	Landfill Gas
MTCO2E	Metric Ton of Carbon Dioxide Equivalent
MWh	Megawatt Hour
NC	North Carolina
NDAA07	National Defense Authorization Act of 2007
NPV	Net Present Value
NREL	National Renewable Energy Laboratory

PNNL	Pacific Northwest National Laboratory
PPA	Power Purchase Agreements
PTC	Production Tax Credit
PV	Present Value
REC	Renewable Energy Certificate
RFI	Request For Information
U.S.	United States
VOC	Volatile Organic Compounds
WARM	WAste Reduction Model
WtE	Waste to Energy

EXECUTIVE SUMMARY

As the nation's largest single consumer of energy, the Department of Defense (DOD) has become a leader in developing American energy. As part of that leadership, DOD has committed to obtaining 25 percent of its electricity from renewable sources by 2025. As our nation becomes more aware of the dangers of energy dependence and the environmental impacts of fossil fuel consumption, DOD is actively seeking partnerships to meet the challenges of energy security. During these tough economic times, large projects are often dominated by the financial bottom line. As a leader in energy security and environmental stewardship, DOD's bottom line includes impacts to national security and the environment. In line with President Obama's "all-out, all-of-the-above" energy strategy, DOD is exploring several renewable energy sources for feasibility. One of these sources is turning waste into energy, WtE.

A leading location of a WtE facility is Fort Bliss, Texas. Fort Bliss is considering a hybrid WtE facility augmented by solar energy in the form of concentrating solar power. With the right energy security partnership, a WtE/CSP facility on Fort Bliss would require no capital or operating costs; therefore, the increased cost of electricity is the overarching cost. Though this cost is significant compared to the current cost of electricity, a WtE/CSP facility provides energy security and environmental benefits to the Army and the community. This Cost Benefit Analysis of a Waste to Energy (WtE)/Concentrating Solar Power (CSP) Hybrid Facility located on Fort Bliss is a comprehensive analysis of the costs and benefits of a WtE/CSP facility to the Army. This thesis monetizes the benefits of energy security and environmental impact, along with the benefits of meeting legislative mandates and meeting installation Net Zero Energy goals.

A WtE/CSP facility on Fort Bliss will assist the Army in meeting multiple Legislative and Presidential mandates for renewable energy production and consumption. Fort Bliss is well located to capitalize on WtE/CSP potential. Similar to wind and solar renewable energy production, WtE/CSP renewable energy production cost more than fossil fuel energy production. Similar to those same forms of energy, there are non-cash

benefits of WtE/CSP renewable energy production that need to be monetized to fully determine the net present value of a project. This thesis estimated the costs and benefits based on Fort Bliss' projected electricity demands, the potential environmental impacts, and the potential energy security benefit. The thesis then conducted sensitivity analysis around potential prices of electricity and variations in the benefit values to explore changes to the net present value of a WtE/CSP project.

This thesis found that though annually the Army will pay more for electricity on Fort Bliss by using a WtE/CSP system, when including the full benefits of energy security and environmental impact, a WtE/CSP facility is a good decision.

THIS PAGE INTENTIONALLY LEFT BLANK

ACKNOWLEDGMENTS

To my advisor, Dr. Daniel Nussbaum, thank you for your wise advice and guidance from proposal development through thesis completion. I thank you for doing your part for this Nations' current and future security. Best wishes to you and your family.

To my second reader, Dr. Eva Regnier, thank you for your patient direction and keen eye through many hours of revisions. You educated me in the process and made me a better writer. Please thank your family for stealing some time to improve me and my thesis.

To my children, Hannah and Colton, thank you for keeping daddy happy and active while I did my best at work. I hope my strong effort to spend lots of time with you will provide many happy memories of our time in this wonderful place. I know I will have fond memories of you during these playful years. I love you always.

I. INTRODUCTION

A. BACKGROUND

1. Importance of Renewable Energy on Fort Bliss

In his State of the Union address on 24 January 2012, President Obama called for an “all-out, all-of-the-above strategy that develops every available source of American energy” (Obama, 2012). The Department of Defense (DOD) has taken up that challenge and become a leader in developing American energy. DOD is the nation’s largest single consumer of energy. In addition to over 100 million barrels of fuel, DOD consumed 3.8 billion kilowatt hours (kWh) of electricity in 2006 at a cost of over $3.5 billion (Defense Science Board, 2008). As our nation becomes more aware of the dangers of energy dependence and the environmental impacts of fossil fuel consumption, DOD chose to lead the way toward energy security. As part of that leadership, DOD set a goal of obtaining 25 percent of its electricity from renewable sources by 2025. Unfortunately, DOD also faces current and projected budgetary constraints. In order to reach this renewable energy goal without spending billions of dollars from a dwindling budget, DOD needs businesses with which to form energy security partnerships. These businesses will build the renewable energy projects on DOD land while DOD agrees to purchase power from the businesses. Forming these partnerships benefits DOD because it has lots of land available and an increasing need for electricity; but it does not have the money or experience to build electrical power facilities. Enticing businesses to build the renewable energy projects to help DOD meet its goals continues to be a challenge. For business, the focus is financial. For DOD, the challenge involves finances, but also includes energy security and environmental stewardship.

Energy security continues to increase in importance. Over 99 percent of electrical energy consumed by DOD originates off of installations (Defense Science Board, 2008). Concerns about rising energy prices, energy demands of critical missions, and threats to

fragile power grids have risen in recent years. Major regional power outages caused the Army to increase focus on energy security to critical missions on installations. Some examples of these power outages follow.

In August 2003, approximately 50 million people in over 9,000 square miles in the northeastern United States and Canada lost electrical power. According to a study by the Defense Science Board, 243 power plants shut down and twenty two nuclear power plants shut down. Though electricity was restored to many areas within several hours, it took almost two weeks for all the power plants to regain full capacity. Some areas lost drinking water when pumps failed because of the outage. In one case, the outage caused a chlorine leak at a chemical plant. In other cases, raw sewage spilled into waterways as the outage caused sewage systems to fail. Amtrak's rail service was disrupted in certain areas due to lack of power. Many gas stations closed due to lack of power, causing long lines at those that remained open. Certain East Coast oil refineries and cellular communication towers shut down due to lack of back-up power. The U.S.-Canadian Border checking systems no longer functioned, causing a severe trucking back log. Investigations determined the main cause of the regional blackout to be improperly trimmed trees near a power line in Ohio (Defense Science Board, 2008). This demonstrates how easily and remotely the power grid can be shut down, and this time by a simple line entangled in a tree.

Another example occurred in September 2011 when over 3 million people in Southern California, Arizona, and Northern Mexico lost electrical power. Nuclear reactors near San Diego were taken offline because of the blackout, and many beaches were closed after 3.2 million gallons of raw sewage spilled from waste water treatment plants that lost power. Outgoing flights from San Diego's main airport were grounded, and freeways were clogged in the midst of 100 degree temperatures. The outage was due to a scheduled maintenance operation in Arizona that inadvertently affected millions more than expected for much longer than expected (Fox News, 2011).

The power grid presents an easy target for sabotage or terrorist activity because the grid remains relatively unprotected. While power plants operate at near peak capacity, the overall distribution system has become very centralized with little

redundancy. With little planning, a small number of saboteurs could shut down power to significant areas for an extended period of time. Insurgents in Iraq used attacks on the power grid as a simple technique to destabilize the government (Defense Science Board, 2008). Similar attacks in the United States would not destabilize our government, but they could cause a very expensive reaction as the government rushes to harden the vulnerable electrical grid system. The grid becomes more vulnerable to cyber-attacks as control systems are increasingly automated.

Over the past three years, the El Paso area has suffered several smaller, localized power outages for various reasons. In March 2009, approximately 100,000 people lost power for three hours after a car crashed into a power line pole. The damaged electric pole carried high voltage wires which touched, causing a safety mechanism to shut down power to those lines (KTSM News, 2009). In 2011, El Paso had multiple power outages. On June 6, two major transmission lines went down causing safety mechanisms throughout the area to begin shutting down power affecting over 163,000 people. Though many regained power in less than an hour, several thousand did not have power restored for almost three hours (KTSM News, 2011a). On June 13, faulty breakers caused a power outage for over 7,500 people (KTSM News, 2011c), and on June 27 mylar balloons caught in power lines caused a power outage for about 4,000 people (KTSM News, 2011b).

Energy security coupled with increasing regulatory mandates for energy consumption prompted the Army to expand its pursuit of renewable energy sources to meet growing requirements. On April 19, 2011, the Army designated Fort Bliss as one of two pilot Net Zero installations for Energy, Waste, and Water. This means Fort Bliss will strive to become Net Zero Energy, Net Zero Waste, and Net Zero Water in the coming years. Net Zero Energy requires Fort Bliss to produce as much energy on-installation as it consumes annually. Net Zero Waste aims to reduce, reuse, and recover waste streams in order to convert them into resources of value with zero solid waste to landfills. Net Zero Water strives to limit consumption of freshwater through conservation and reclamation (Guiney, 2011).

To address energy security concerns, meet legislative mandates, and achieve Net Zero installation goals, Fort Bliss is actively seeking on-installation renewable energy projects. This thesis focuses on one part, waste to energy (WtE), of the installation's overall renewable energy strategy. WtE is the conversion of waste into energy. Fort Bliss has shown interest in having a WtE facility built on its installation by both issuing a request for information to industry in 2011 (Tomlinson, 2011b), and taking steps to prepare an environmental impact statement (Department of the Army, 2012). Construction of a WtE facility on Fort Bliss provides a large step toward meeting the Army's mission of achieving 25 percent renewable energy consumption by the year 2025. It also meets Fort Bliss' mission to become Net Zero Energy and Net Zero Waste by 2020. A WtE facility actually goes well beyond Fort Bliss' Net Zero Energy mission. That mission requires the installation to become Net Zero Energy based on 2003 baseline energy consumption. A WtE facility makes Fort Bliss truly Net Zero Energy by producing 100 percent of its electricity based on this year's electricity consumption and every year's electricity consumption for the foreseeable future.

2. Legislative Mandates Governing Renewable Energy and DOD

The Energy Policy Act of 2005 (EPACT05) requires federal agencies to obtain at least 7.5 percent of their electricity from renewable sources beginning in fiscal year (FY) 2013. Proposed legislation, Senate Bill 1321, would have increased this requirement to 15 percent by FY 2015. The Senate Bill eventually became law as the Energy Independence and Security Act of 2007, but the renewable energy provisions were not included in the final bill. These provisions are likely to be introduced in future legislation.

The National Defense Authorization Act of 2007 (NDAA07) requires that 25 percent of DOD's electricity come from renewable sources by 2025. Prior to passage, DOD had set similar voluntary renewable energy goals. The Army adopted this target while the Navy set an aggressive goal of 50 percent electricity coming from renewable energy by 2020.

Executive Order 13423 reiterates the requirements of EPACT05 and adds that 50 percent of the renewable energy sources be “new” sources. New sources are defined as those put into service after January 1, 1999. The executive order requires to the extent feasible, that the renewable energy be produced on federal property for use by the federal government. E.O. 13423 defines renewable energy as energy produced from solar, wind, biomass, landfill gas, ocean (including tidal, wave, current, and thermal), hydrokinetic, geothermal, municipal solid waste (MSW), or new hydroelectric generation capacity achieved from increased efficiency or additions of new capacity at an existing hydroelectric project (Pacific Northwest National Laboratory, 2009).

Executive Order 13514 requires Federal agencies to establish greenhouse gas emission reduction targets for 2020 (U.S. EPA, 2011a). In January 2010, DOD announced a target greenhouse gas emissions reduction of 34 percent by 2020. This reduction applies to facilities and fleet vehicles exempting tactical vehicles (Department of Defense, 2010).

3. Army Energy Security Strategy

The Strategic Energy Security Goals of the Army Energy Security Implementation Strategy are (Army Senior Energy Council, 2009):

- Reduce energy consumption
- Increase energy efficiency across platforms and facilities
- Increase use of new renewable and alternative energy
- Assure access to sufficient energy supplies
- Reduce adverse impacts on the environment

The Army considers energy security a critical priority for Army installations, weapon systems, and operations. The core characteristics defining the energy security necessary for the full range of Army missions include supply, surety, survivability, sufficiency, and sustainability. These characteristics are defined below (Army Senior Energy Council, 2009).

Supply refers to accessing alternative and renewable energy sources available on installation. The military often focuses on solar, wind and geothermal, but WtE qualifies as one of Fort Bliss' multiple renewable energy resources.

Surety refers to preventing the loss of access to power and fuel sources. Due to dependence on the commercial electricity grid for installation energy, Fort Bliss is vulnerable to service disruptions and critical missions face serious and growing risk.

Survivability refers to ensuring resilience in energy systems meaning the ability to withstand or recover quickly from electricity disruption. Since a connection to the off-installation grid remains with the construction of a WtE facility, Fort Bliss can draw power from the outside grid in the unforeseen event that a WtE facility sustains a loss of power.

Sufficiency refers to providing adequate power for critical missions. Critical missions and power requirements of those missions can change over time. Since a WtE facility does not experience intermittent production of power, which is normal for solar and wind renewable energy projects; an on-installation WtE facility can provide 100 percent of the electricity needed by Fort Bliss 100 percent of the time.

Sustainability refers to promoting support for the Army's mission, its community, and the environment. In regards to energy security, it is promoting the success of critical missions while considering the impact to the environment and the surrounding community. Reducing the environmental impact of producing installation electricity has become increasingly important. The Army committed itself to being good stewards of our environment. Energy used by installation facilities accounts for 26 percent of DOD's energy use, but it accounts for 40 percent of DOD's greenhouse gas emissions (Deputy Under Secretary of Defense (I&E), 2011). Many factors determine the exact amount of greenhouse gas emitted by landfills containing municipal solid waste.

4. Status of Electricity at Fort Bliss

In FY2010, Fort Bliss consumed 312,583 megawatt hours (MWh) of electricity. The base energy load was 30 to 40 megawatts with 65.8 megawatts peak demand

(Tomlinson, 2011a). Army reorganization efforts resulted in Fort Bliss experiencing 300 percent population growth and a doubling of on-installation building square footage from 2005 to 2012 (Toufic, 2010). As population and facility expansion continue, electrical demand will continue to rise. Along with increased demand comes increased cost of electricity.

El Paso Electric Company provides Fort Bliss electricity at a special rate, as described below. The average El Paso resident pays $0.1133 per kWh for electricity. Electricity sells on the commercial market in El Paso for $0.0906 per kWh and $0.0685 per kWh in the industrial contracts on average. Fort Bliss pays a blended rate of $0.060 per kWh (Tomlinson, 2011b). Their rate plan has multiple tiers and various charges, but this analysis uses the blended rate in calculations and allows the decision maker to alter the blended rate in the Excel analysis tool. Fort Bliss benefits from both large scale industrial contracting and electricity rate discounts granted to military installations by the State of Texas under the Military Preparedness Act in 2003. The law provides a 20 percent electricity rate discount to military installations. The residential customers pay a little extra each year to offset the discount (Schladen, 2010a).

5. Status of Waste to Energy and Concentrating Solar Power

Concentrating Solar Power (CSP) uses mirrors to concentrate solar energy to heat liquid which will be cycled through a common steam power generator and combined with the steam from a WtE facility. Once the transfer of heat completes, the heat transfer system recycles the liquid back through the mirror concentrating system to continue the process. There are different types of CSP systems and different methods for WtE. The analysis by the National Renewable Energy Laboratory of a potential hybrid CSP and WtE facility for Fort Bliss recommends the parabolic trough CSP system combined with a mass burn WtE facility (WorleyParsons, 2011).

A mass burn WtE facility produces electricity by burning municipal solid waste, commercial waste, or other forms of waste. WtE is a proven source of renewable energy. Worldwide, over 900 WtE facilities produce 130 billion kWh of electricity and process approximately 200 million tons of municipal solid waste per day. In the United States,

86 WtE facilities operate in 24 states and process over 97,000 tons per day of municipal solid waste (Jacobi, 2011). The proposed WtE facility on Fort Bliss will be a mass burn facility which represents the most mature of all WtE technologies. Figure 1 shows the normal layout for a mass burn WtE facility (WorleyParsons, 2011). The waste gets deposited into a holding facility then craned into the furnace where the temperature can vary by the design of the facility. The furnace powers a boiler system that produces steam for conversion to electricity. The air eventually moves through multiple detoxification stages to ensure the emissions fall within Environmental Protection Agency (EPA) guidelines.

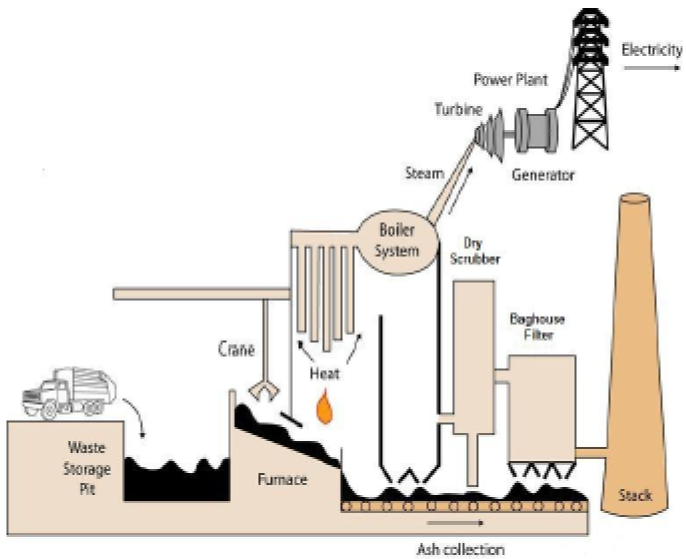

Figure 1. Typical Layout for a Mass Burn WtE Facility

Among DOD installations, few locations have the three attributes needed for an economically viable WtE facility:

(1) The facility must have enough reliable feedstock to burn in order to produce electricity at a competitive rate. Electricity rates vary city by city and state by state, but generally larger WtE facilities produce electricity at more competitive rates than smaller ones. It typically takes a city with a population greater than 500,000 to produce enough municipal solid waste along with construction and industrial waste as feedstock for a WtE plant. El Paso has a population of 649,121 (U.S. Census Bureau, 2012). El Paso

and Fort Bliss could provide an estimated 1 million tons annually of feedstock for a WtE facility on Fort Bliss (Tomlinson, 2011b). A WtE facility owner must secure contracts with the local municipalities to ensure the availability of feedstock before construction of the facility begins. The City of El Paso has been a huge supporter of the Fort Bliss installation. This thesis assumes a WtE facility owner and the City of El Paso will be able to reach an agreement on supplying feedstock for the facility.

(2) The location of a WtE facility must be within sixty miles from the feedstock to be economically feasible. Fort Bliss sits immediately adjacent to the City of El Paso providing an excellent location for a WtE facility. Fort Bliss has a vast amount of suitable land and already has a non-DOD utility, the Kay Bailey Hutchinson Desalination plant, located on the installation. The desalination plant represents a public-public partnership that provides potable water to the region (Toufic, 2010).

(3) A WtE facility needs a reliable consumer of its electricity. Whether an installation, city, county, or utility purchases the electricity generated by a WtE facility, the owners of the facility need power purchase contracts to ensure the economic viability of a WtE facility. Fort Bliss' long term Net Zero Installation goals include a WtE facility, but the economic feasibility remains to be shown.

6. Status of Municipal Solid Waste at and Near Fort Bliss

Fort Bliss produces approximately 14,000 tons of municipal solid waste annually (Pacific Northwest National Laboratory, 2009). Even with the anticipated 300 percent population growth, Fort Bliss will not generate enough municipal solid waste to serve as adequate feedstock for a WtE facility to produce electricity at a competitive rate (McCarthy, 2011). Further reducing its contribution to feedstock needed by a WtE facility, Fort Bliss recently began a campaign to eliminate as much waste as possible by reducing, reusing and recovering its waste stream.

Recycling plays a significant role in reducing the waste stream. While the national average percentage of municipal solid waste recycled has more than doubled in the past twenty years, recycling rates still sit at approximately 34 percent (U.S. EPA, 2011c). Even with increased recycling efforts planned by Fort Bliss, there is a realistic

limit to the percentage of waste that can be recycled or reused. Fortunately, Fort Bliss' Net Zero Waste goals include converting waste into energy, but to do so economically on Fort Bliss would require including waste from nearby El Paso.

El Paso discards over 415,000 tons of municipal solid waste annually (Pacific Northwest National Laboratory, 2009). Coupled with other waste discarded, which in most regions is about 1.86 times as much by mass as municipal solid waste, El Paso discards an estimated 1.1 million tons of waste annually into landfills (Waste Permits Division, 2006).

In August 2010, health concerns over the impacts of landfills voiced by residents in Sunland Park, New Mexico prompted the El Paso City Council to reject a landfill contract proposed by a New Mexico landfill company that would have paid the city $2.5 million annually to continue disposing of its commercial waste in the landfill in Sunland Park. In addition to the lost revenue, the city must spend $18.5 million to prepare their own landfills to handle the added waste disposal. This decision highlights the concern that citizens and lawmakers have over the long term health and environmental impacts of landfills (Garcia, 2010). As concerns about the impacts of landfills grow, available land for landfills shrinks causing prices for landfill disposal to continue to increase.

7. Status of WtE/CSP Hybrid Facility on Fort Bliss

According to a Request for Information response, necessary conditions for a WtE/CSP hybrid power facility on Fort Bliss to be economical are that it:

- consume 1 million tons of waste annually;
- produce approximately 664,000 MWh of electricity annually;
- charge $0.090 per kWh blended rate for electricity; and
- charge $19 per ton for waste disposal (as specified by Fort Bliss).

The facility requires 20 acres for a WtE portion and 50 to 100 acres for the CSP portion (McCarthy, 2011). The facility uses private capital from an industry developer that requires no capital investment from Fort Bliss or the Army; in exchange Fort Bliss enters into a 20 year power purchase agreement which has higher electricity rates than Fort Bliss currently pays.

B. THESIS FOCUS

1. Benefits of the Thesis

The focus of this study is to provide a comprehensive analysis of the costs and benefits to Fort Bliss of a WtE/CSP hybrid power facility. Additionally, this thesis provides a methodology to quantify in financial terms achieving renewable energy goals and attaining energy security. This capability can benefit hundreds of renewable energy projects across DOD. This methodology also provides a more comprehensive way to evaluate alternative energy projects.

2. Research Questions

1. What are the future energy demands for Fort Bliss?
2. What are the future energy costs for Fort Bliss under the current energy production methods?
3. What are the future energy costs for Fort Bliss under a WtE/CSP energy production method?
4. What are the future waste disposal costs for Fort Bliss?
5. What are the future waste disposal costs for Fort Bliss under a WtE/CSP energy production method?
6. What monetized values are associated with achieving the legislated mandates?
7. What monetized values are associated with the environmental impacts of the proposed facility?
8. What monetized values are associated with achieving DOD and Army goals of energy supply, surety, survivability, sufficiency, and sustainability?
9. The above questions support the main question: Do the benefits of a WtE/CSP facility at Fort Bliss outweigh the increased electricity cost over the life cycle of the facility?

3. Thesis Scope

The purpose of this study is to provide an analysis of the costs and benefits to the Fort Bliss installation of a WtE/CSP Hybrid Facility located on Fort Bliss.

This study will estimate the future energy and environmental cost to the installation based on increased cost of electricity provided by the facility and projected electricity demands. This study will also provide financial estimates of benefits to the installation. These benefits include, but are not limited to, achieving legislated mandates for electricity consumption, achieving DOD goals of on-installation energy production, achieving Army Net Zero Energy goals, environmental benefits of landfill avoidance, and energy security achievement.

C. THESIS ORGANIZATION

The current chapter discussed the problem of energy security, the legislation that mandates renewable energy use by DOD, and the Army's strategy toward obtaining energy security. It also provided status of electricity consumption at Fort Bliss, WtE technology, municipal solid waste near Fort Bliss, and the proposed WtE/CSP hybrid power facility for Fort Bliss.

Chapter II reviews the literature relevant to this thesis, including studies conducted by the National Renewable Energy Lab and a report published by the Defense Science Board on energy security.

Chapter III projects electricity consumption based on recent population and facility growth at Fort Bliss and estimates future costs based on historic electricity rates.

Chapter IV monetizes non-cash benefits of a WtE/CSP facility to Fort Bliss. These benefits are energy security, environmental benefits, and meeting legislative mandates.

Chapter V provides sensitivity analysis for key variable factors and provides results on the costs and benefits of a WtE/CSP facility.

Chapter VI concludes and suggests areas for future study.

II. LITERATURE REVIEW

<u>Renewable Energy Opportunities at Fort Bliss, Texas</u>, January 2009, Pacific Northwest National Laboratory (PNNL).

PNNL prepared an overview of renewable resource potential on the Fort Bliss installation for the Army Installation Management Command Headquarters (IMCOM). IMCOM funded the study following the 2005 DOD Renewables Assessment. The study provides an overview of federal renewable requirements. It discusses the economic environment for renewable projects on Fort Bliss. The study based project feasibility on installation electricity costs. Wind energy and WtE projects surfaced as the two most promising types of renewable energy projects.

PNNL analysis showed that small WtE projects using only waste from Fort Bliss are uneconomical based on current electricity prices. Using the assumption of availability of municipal solid waste from nearby communities of El Paso or Las Cruces provided enough waste to make a larger project economically feasible. The study noted that a smaller project may have merit based on the benefits of energy security or waste reduction.

The PNNL study discussed WtE opportunities at Fort Bliss. It assumed a maximum economic transport distance of sixty miles which does include both El Paso and Las Cruces. Other PNNL considerations included the amount of electricity that could be produced from the municipal solid waste sources. Not included in their study was the availability of commercial and construction waste. The study did consider other sources of feedstock for a WtE facility such as crop residue, manure from large animal feed lots, forest biomass, and dedicated crops. No other feedstock provides economical promise, though biosolids from local wastewater treatment plants may provide an additional benefit of the power facility.

The study recommended Fort Bliss pursue generating electricity from municipal solid waste. It recommended Fort Bliss not pursue other renewable energy projects based on economic feasibility at the time.

Analysis of Hybrid Concentrating Solar Power (CSP)/Waste-to-Energy(WtE) Plant with Common Power Block, January 2011, National Renewable Energy Laboratory.

In January 2011, the National Renewable Energy Laboratory funded WorleyParsons Group to determine the technical feasibility and economics of operating a hybrid WtE/CSP power facility. The study focused more on the technical options of the power production and on facility configurations, and less on the economics of the options. The study recommended mass burn as the most commercially viable technology for a hybrid WtE/CSP power facility. Assuming a $20 per ton tipping fee, the study estimated the cost of electricity to the installation between $0.105 and $0.113 per kWh. The study discusses the basics of mass burn WtE facility layout, the composition of municipal solid waste feedstock, the possibility of using heat energy from the facility in addition to electrical energy, and comparisons of a WtE stand-alone facility versus the proposed hybrid WtE/CSP facility. The study concluded a hybrid WtE/CSP facility is technically mature and feasible.

Municipal Solid Waste Generation, Recycling, and Disposal in the Unites States: Facts and Figures for 2010, U.S. Environmental Protection Agency, 2011.

The report provides collected and reported data on the generation and disposal of municipal solid waste in the United States from 1960 to 2010. Along with tonnage of waste generated, the report discusses tonnage and recycling percentages of waste at the national level.

Response to Request for Information—Net Zero Energy Fort Bliss, Wheelabrator Technologies Inc., October 2011.

Fort Bliss sent a request for information to the WtE industry with specific questions about the economics of a hybrid WtE/CSP power facility. The response from Wheelabrator Technologies included information about electricity cost per kWh, feedstock availability, power generation, financing, and power purchase agreements. Wheelabrator also introduced the possibility of providing process steam for heating and cooling of buildings on Fort Bliss as an additional benefit of a WtE/CSP project. For

electrical cost, the Wheelabrator response stated that the $0.090 per kWh was the best price a WtE/CSP facility could provide. The Wheelabrator response used $19 per ton as a WtE tipping fee which is a restriction given in the Fort Bliss RFI. The response assumed that the local area could provide 1 million tons annually of waste feedstock.

Report of the Defense Science Board Task Force on DOD Energy Strategy, Defense Science Board, February 2008.

The Undersecretary of Defense for Acquisition, Technology and Logistics directed the Defense Science Board to investigate several energy related issues facing DOD including identifying alternative energy sources for facilities. One of the report's conclusions highlighted military installations' dependence on the commercial power grid with all its vulnerabilities. This dependence places critical military and homeland defense missions at risk. The report recommended further study on options to mitigate installation energy risk like higher efficiency, islanding, renewable resources, distributed generation, and greater commercial grid reliability. The report covered the recent major regional power outages as well as consequences of prolonged power outages. The report drew similarities between DOD's energy challenges and those in the nation at large, since improvements to one will benefit the other.

Energy Security: Army Priority and National Imperative, Office of the Assistant Secretary of the Army (Installations and Environment), April 2010.

The briefing spotlighted the emphasis placed on energy security and the initiatives that are underway throughout the Army. It contains a list of initiatives at Fort Bliss which includes a potential WtE/CSP facility. Because it is focused on Army expeditionary energy, it describes many emerging technologies for deployed forces. The briefing discusses the Army Senior Energy Council and the development of the Army Energy Security Implementation Strategy.

GovEnergy Conference Brief: Fort Bliss Renewable Energy Program, Fort Bliss Directorate of Public Works, August 2010.

The brief captures facts from Fort Bliss' recent expansion making it the fourth largest (by population) DOD installation with a 300 percent increase from 2005 to 2012. Fort Bliss' building square footage will double from roughly 10 million to 20 million square feet.

III. COST ESTIMATES FOR PROVIDING ENERGY

A. PREDICTED ENERGY PRICES FOR FORT BLISS UNDER STATUS QUO

If a WtE/CSP facility similar to the recommendation in the response provided to Fort Bliss by Wheelabrator Technologies Inc. gets approved and built, the net monetary cost to the Army is the difference between the cost of electricity plus tipping fees under a WtE/CSP system and the status quo, including changes over time in electricity prices and electricity demands.

Because of the recent and planned growth of Fort Bliss in both population and facility square footage, historic electricity demand data could not be used to accurately model future electricity demand. Past electricity demand data and future demand projections based on planned population and facility growth were collected from a briefing given in 2010 by the Chief of Business Operations and Integration Division of the Fort Bliss Directorate of Public Works (Toufic, 2010). Since energy efficiency and conservation efforts are ongoing at Fort Bliss, this thesis uses a projected demand based on successful energy conservation efforts. Projections are provided until 2025 with demand beginning to level off after 2020 (Toufic, 2010). In the absence of reliable data to continue projections out further and since the projections level off before 2025, electricity demand beyond 2025 is held at 500,000 MWh as seen in Figure 2.

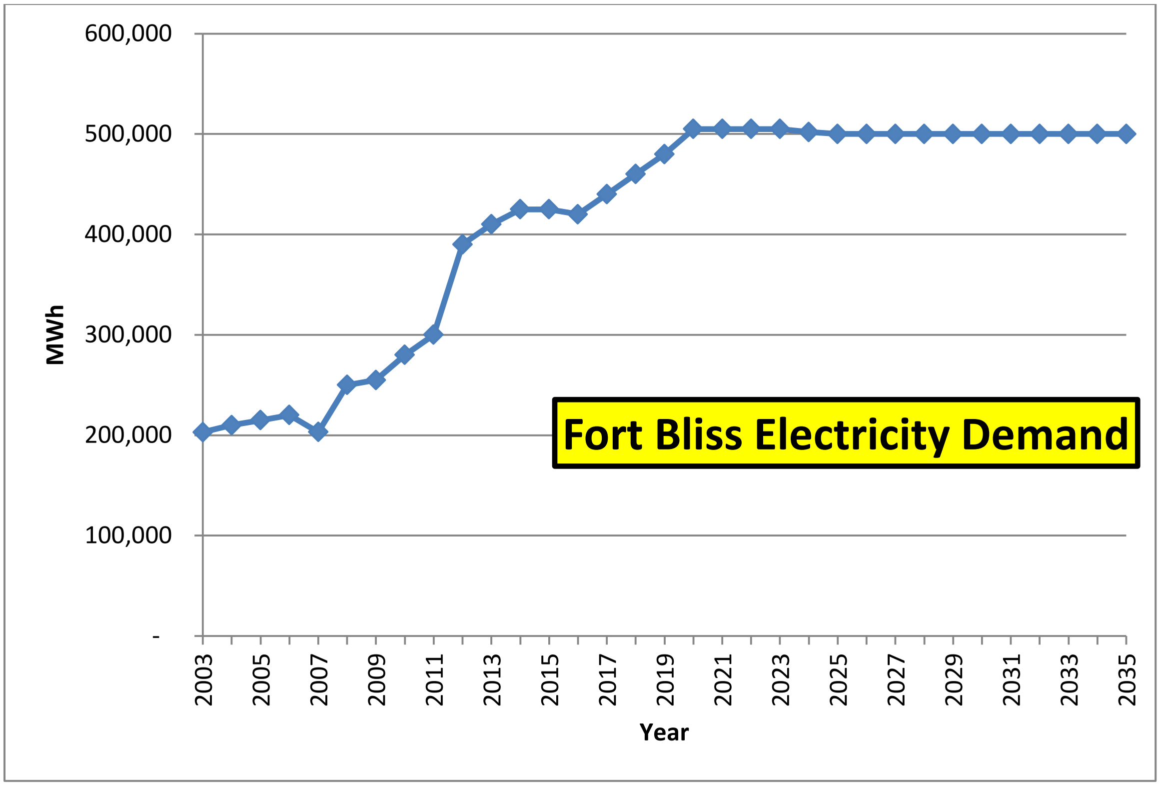

Figure 2. Fort Bliss Electricity Demand Projections

Together with the future electricity demand predictions for Fort Bliss, the future price of electricity is necessary to calculate the annual cost of electricity for the installation. Under current contractual terms, Fort Bliss pays $0.060 per kWh for electricity. Toward the end of each contract Fort Bliss negotiates a rate schedule with El Paso Electric to determine the price the installation pays for electricity. This price has traditionally been in the vicinity of the industrial rate for electricity, which is historically well below residential or commercial rates. Historical price data from the Energy Information Administration (EIA) on the national average retail industrial price of electricity from 1997 through 2011 were used to determine the annual rate of increase (U.S. EIA, 2012). We used the Consumer Price Index (CPI) from the Bureau of Labor Statistics to adjust for inflation (Bureau of Labor Statistics, 2012). Applying the CPI indices to the EIA data shows that over the past ten years the real, inflation-adjusted, rate fluctuates between $0.064 and $0.068 per kWh, exhibiting very low volatility. Using

linear regression shows the real annual increase in industrial price of electricity has been 0 percent as seen in Figure 3. Therefore, 0 percent will be used as the assumed future rate of growth in real electricity prices for Fort Bliss.

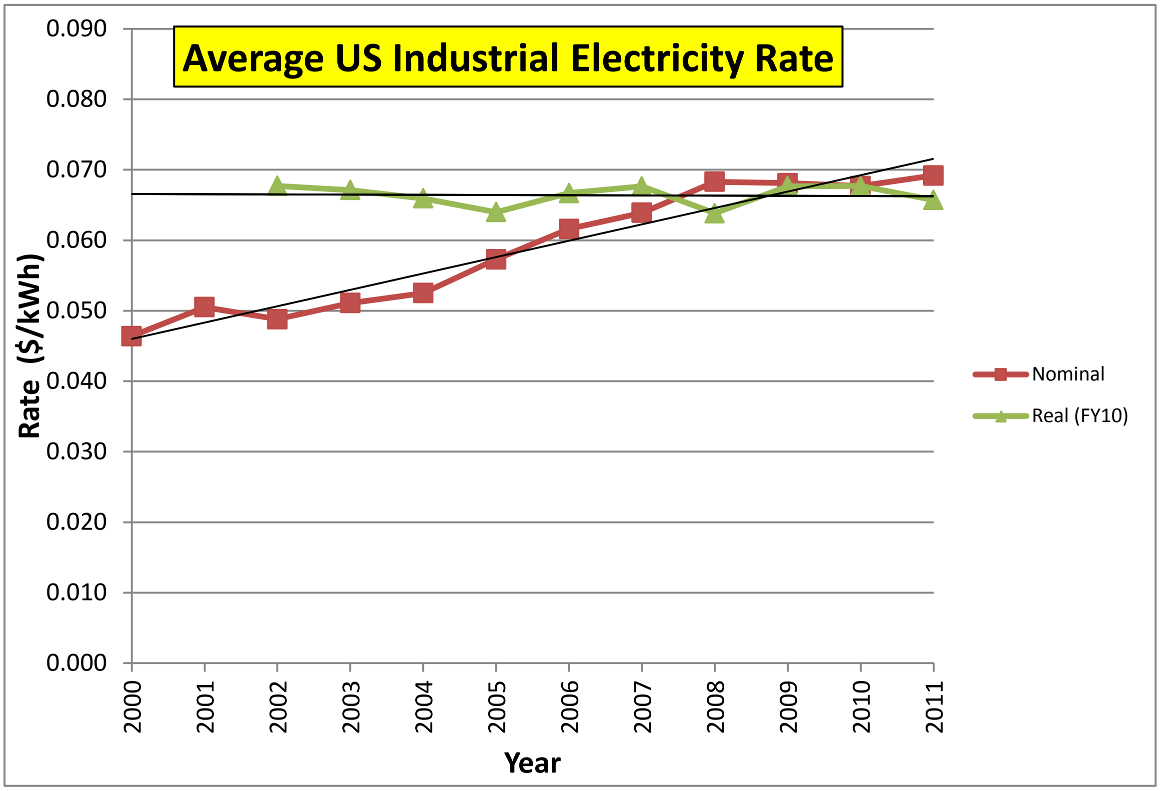

Figure 3. Average U.S. Industrial Electricity Rate ($/kWh) nominal vs. real

B. PREDICTED ENERGY PRICES FOR FORT BLISS UNDER WTE SYSTEM

Based upon a $19 per ton tipping fee restriction and the assumption of a power purchase agreement, the proposed WtE facility will provide Fort Bliss with electricity at a blended rate of $0.090 per kWh. The annual increases of this rate are negotiable and sensitivity analysis can be done to determine a break-even point for the installation with other benefits in consideration. Since historic industrial electricity rates have only increased with inflation on average, this analysis assumes the rates for WtE/CSP produced electricity will increase with inflation only.

C. FUTURE WASTE DISPOSAL COSTS FOR FORT BLISS

Before determining how much Fort Bliss will pay in future disposal costs, the amount of waste that Fort Bliss will dispose of must be determined. Historical data on Fort Bliss municipal solid waste disposal was not available to build time series prediction models. Data on national waste disposal from the Environmental Protection Agency (U.S. EPA, 2011c) were used to fit a Double (Brown) Exponential Smoothing Model (SAS Institute, Inc., 2009). This model fit the data well with an AIC value of 188 and an R^2 value of 88 percent. This thesis assumed Fort Bliss would follow the national average municipal solid waste disposal rates. The Fort Bliss disposal tonnage was divided by the national average disposal tonnage to produce a ratio to adjust future predictions. Figure 4 shows the estimated discarded waste from Fort Bliss.

A similar Double (Brown) Exponential model fit to the discarded waste of El Paso showed a potential setback in the continued economic productivity of a WtE facility. After the year 2020, the model shows a drop in available feedstock below the target 1 million tons annually desired by the proposed WtE facility. This estimate is consistent with the national decline in municipal solid waste which began in 2005, but the availability of waste from nearby communities was not considered in this thesis. If El Paso cannot meet the 1 million tons annually of waste, a WtE/CSP facility can get the needed feedstock from nearby communities. For example, the city of Las Cruces which is fifty miles away disposes of approximately 300,000 tons of municipal solid waste annually (Pacific Northwest National Laboratory, 2009).

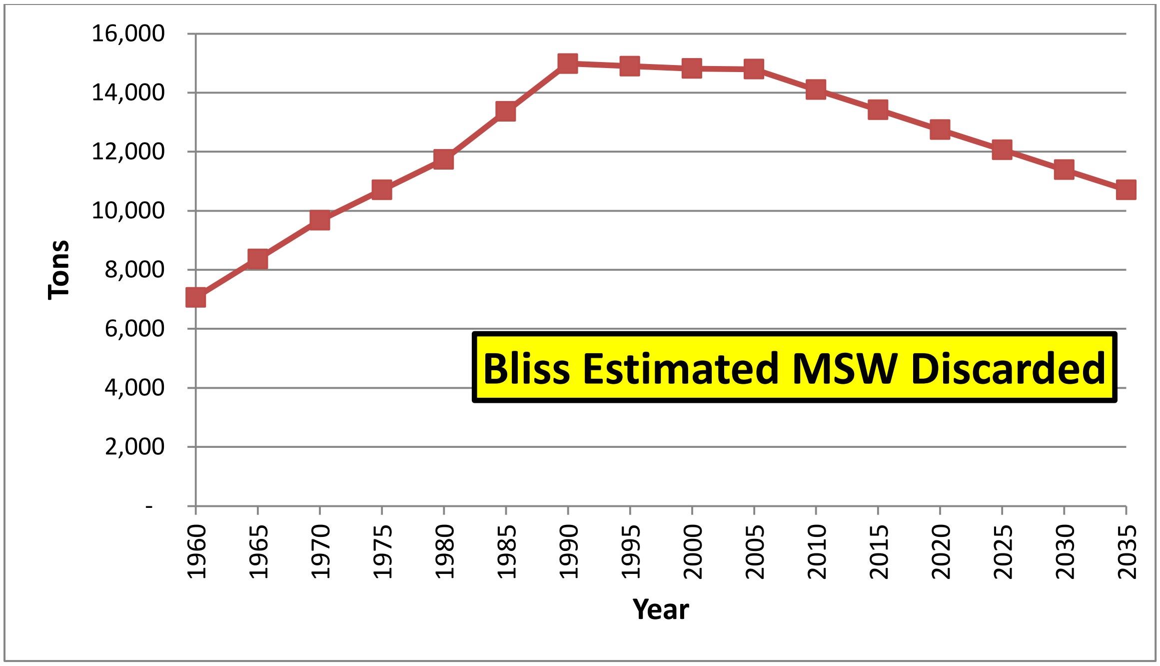

Figure 4. Estimated Municipal Solid Waste Tonnage Discarded from Fort Bliss

Tonnage of municipal solid waste coupled with the tipping fee per ton determines the cost of future waste disposal for Fort Bliss. Tipping fees have increased over 200 percent since 1985. From 1985 to 1998, the national price paid for tipping fees increased about 7 percent annually. Many new environmental regulations took effect during that time period. Tipping fee increases began to level out after 1998 at approximately 1 percent annually (Repa, 2006).

Currently, Fort Bliss pays $19 per ton of municipal solid waste to dispose of its waste in a nearby landfill. This fee ranks very low compared to tipping fees across the nation. In 2010, the national average tipping fee was $43.99 (Repa, 2011). In August 2010, the El Paso City Council took steps to regulate the disposal of El Paso waste. In 2014, all commercial and municipal solid waste produced in El Paso must be disposed of in the landfills owned by the City of El Paso. This change increases the tipping fee per ton of waste significantly. Currently, landfills owned by the City of El Paso charge $26 per ton of waste (Schladen, 2010b). Sensitivity analysis in Chapter V Section B includes the recent average annual increase of 1.68 percent and will show the effects of potential tipping fee increases on future cost of waste disposal.

D. FUTURE WASTE DISPOSAL COSTS FOR FORT BLISS UNDER WTE SYSTEM

The proposed WtE/CSP facility currently has a tipping fee of $19 per ton for waste disposal. This fee will increase annually as a result of contract negotiations between Fort Bliss and a WtE facility owner. A WtE facility has the long term economic advantage over traditional landfills of not needing additional acreage to store the waste over time. Sensitivity analysis in Chapter V Section B evaluates the potential savings based on differences in waste disposal tipping fees between a WtE facility and City of El Paso landfills.

IV. BENEFITS

In the following paragraphs, we present the methodologies for monetizing the non-cash benefits of energy security, emissions reduction, meeting legislative mandates, and meeting installation goals. Benefits are estimated by several methodologies: Federal law such as the renewable energy production tax credit (PTC); financial markets such as the dollars per Metric Ton of Carbon Dioxide Equivalent (MTCO2E) and the price of renewable energy certificates (RECs); and pair-wise comparisons of different benefit streams, these pair-wise rations can be adjusted by the decision maker in the Excel analysis tool accompanying this thesis.

A. ENERGY SECURITY BENEFITS

This section describes the methods used to measure the benefits provided by a Fort Bliss WtE facility toward energy security which has core characteristics of supply, surety, survivability, sufficiency, and sustainability.

1. Achieving Energy Supply

Energy supply refers to having alternative and renewable energy sources available on installations. It is hard to place a monetary value on energy supply because supply is a characteristic of a larger non-cash goal of energy security.

This thesis chose the proxy of the federal renewable energy production tax credit to measure the benefit of achieving energy supply. This proxy seems reasonable because it is a value that the federal government implicitly placed on renewable energy production. In 1992, the federal government first established the renewable energy production tax credit. Congress has renewed the tax credit several times most recently in February 2009 under House Resolution 1. The credit current value stands at $0.011 per kWh for energy production from municipal solid waste resources (DSIRE, 2011).

To remain conservative with the valuing of benefits, only the electricity produced by a WtE and consumed by Fort Bliss will be credited as a benefit of a WtE facility to energy supply. A WtE facility will produce over 160,000 MWh of electricity that will be

sold to consumers other than Fort Bliss. The Fort Bliss consumption increases sharply over the first five years of the contract as populations and facilities continue to be added to the installation. Then the electricity consumption increases at a much slower rate beyond 2020. At the given production tax credit the benefit value varies between $3.5 million in 2015 to $1.2 million in 2035 (FY10) using an inflation rate of 3 percent and a discount rate of 3 percent.

2. Achieving Energy Surety

Of the five core characteristics of the Army Energy Security goal, surety encompasses the one that is most commonly understood. When people think of energy security they most often think of ensuring uninterrupted power to installations. However, monetizing the benefit of energy surety presents a challenge. We could not find a reasonable proxy with available data. For this thesis, the value of surety will be considered relative to the core characteristic of supply. In the calculations, we estimate the value of surety as equal to supply and sometimes twice the value of supply, but allow the decision maker to input their own value in the Excel analysis tool accompanying this thesis.

3. Achieving Energy Survivability

A WtE/CSP facility adds a great amount of resilience to the Fort Bliss energy systems as would any power facility located on installation. Resilience comes from being able to disconnect from a fragile grid system during times of power outages and continue to provide power to Fort Bliss. Resilience also comes from having the ability to connect to the off-installation electric grid system should an unforeseen disaster disrupt electricity production of a WtE/CSP facility. Monetizing this benefit proves to be difficult. The cost of providing an equivalent level of resilience without an on-installation facility is composed of the cost of back-up power generators, the cost of storage and use of fuel for generators, possibly a smart grid system for rerouting of available power, and the potential cost of loss of power over time. For the purpose of this thesis, we value survivability as a multiple of the value of energy supply. We begin arbitrarily at half the value of energy supply and explore sensitivities to that value.

4. Achieving Energy Sufficiency

At times, the Army Energy Security core characteristics seem redundant. Achieving energy sufficiency refers to ensuring critical missions receive power and achieving energy surety refers to preventing the loss of access to power and fuel sources. It becomes difficult to distinguish between the two when attempting to monetize their benefits. In order to prevent artificial inflation of the benefits of a WtE facility, energy sufficiency will be assigned a value of zero.

5. Achieving Energy Sustainability

While sustainability is one of the five core characteristics of the Army Energy Security mission, the Environmental and Health Benefits section discusses the overall impact of the benefit to the local and global environment; therefore, the benefit of sustainability is not measured separately.

B. ENVIRONMENTAL AND HEALTH BENEFITS

Many of the environmental and health concerns with landfills stem from the emitting of landfill gas (LFG) into the air and the leaching of pollutants into groundwater. LFG contains methane, carbon dioxide, volatile organic compounds (VOC), and hazardous air pollutants (HAPs) that can affect the environment and health of the nearby population. The EPA lists methane and carbon dioxide as greenhouse gases that contribute to global climate change. VOC emissions contribute to smog formation which can damage vegetation and cause respiratory problems in people. Exposure to HAPs can also cause several health concerns in people to include cancerous illness, respiratory illness, and central nervous system damage (U.S. EPA, 2011b).

The EPA Waste Reduction Model (WARM) allows the calculation of greenhouse gas emission reductions based on the projected tonnage of waste diverted from local landfills and combusted in a WtE facility (U.S. EPA, 2012). The normal characterization of waste landfilled in Texas shows that municipal solid waste accounts for approximately 35 percent of landfilled waste. Commercial waste represents 33 percent followed by Construction and Demolition waste at 19 percent (Waste Permits Division, 2006). These various waste streams were further broken down into material types such as paper, wood,

food, glass, yard trimmings, branches, mixed organics, and mixed plastics. Tonnages based on their percentages of the overall landfilled waste were entered into WARM, which estimated that the Fort Bliss WtE facility reduces greenhouse gas emissions by 264,025 MTCO2E annually. This amount of reduction equates to removing the annual emissions of over 51,000 passenger vehicles or conserving over 29 million gallons of gasoline. MTCO2E is a common measurement used for tracking greenhouse gas emissions and reductions. MTCO2E emission reductions have social and environmental benefits, whose equivalent monetary value may be inferred from market prices for carbon credits. More detail of the WARM methodology and inputs are found in Appendix A.

The carbon credit concept began as a result of increased awareness of the damaging effect greenhouse gases have on the environment. The Kyoto Protocol formalized the concept by proposing capping total annual emissions and letting emission credits be traded on the open market. In the United States, which did not agree to the Kyoto Protocol, the price for emission credits remains very low due to legal challenges to regulate emission totals. The price for emission credits in Europe and worldwide, signals the potential price for emission credits in the United States should political or cultural changes occur. In 2010, the average price per MTCO2E on the Chicago Climate Exchange was $0.10. The average price per MTCO2E on the global voluntary carbon market during the same year was $6.00 (Peters-Stanley, Hamilton, Marcello, & Sjardin, 2011). Recent activity in regional carbon markets signal even more potential for the price per MTCO2E to increase. In July 2012, the Australian carbon pricing mechanism will begin with an initial fixed price of $23 per MTCO2E (Bond University, 2012). If the California climate legislation AB32 survives all legal challenges, it will create the world’s second largest carbon market which could cause prices per MTCO2E to rise (Environmental Leader, 2011). To remain conservative with benefit estimations, the 2010 average price of $0.10 is set as the default price per MTCO2E.

On the low end of the range, $0.10 per MTCO2E, the benefit of reduced greenhouse gas emissions due to a WtE/CSP facility on Fort Bliss equates to $0.4 million (FY10) over the 20 year power purchase agreement. On the high end at $6.00 per MTCO2E, the greenhouse gas emission reductions are valued at over $21.7 million

(FY10) over the 20 year power purchase agreement using an inflation rate of 3 percent and a discount rate of 3 percent. Since Fort Bliss would not produce all of the waste, it can be argued that it should not claim all the benefit of the emission reductions. However, without DOD's push to find more renewable energy solutions and the Fort Bliss support in providing land and a reliable power purchase customer, a WtE/CSP facility would not get built near El Paso in the near future. This thesis credits 100 percent of the value of greenhouse gas emission reductions from a WtE/CSP project to Fort Bliss and explores sensitivity of this value to the price of MTCO2E.

C. MEETING LEGISLATIVE MANDATES BENEFITS

In order to accomplish the congressionally mandated goal that 25 percent of installation electricity consumed comes from renewable sources by 2025, the Army will need to consume 2.1 million MWh annually of renewable energy (Lopez, 2011). From a WtE/CSP facility project alone, projections seen earlier in the cost section show that Fort Bliss will consume 500,000 MWh annually beginning around 2020. This consumption amounts to over 20 percent of the entire Army's mandate. No penalties for not meeting the mandate were set by Congress, making it difficult to monetize the actual value. Since Fort Bliss buys electricity at very low rates and tipping fees in the area are among the lowest in the nation, the legislative mandates, not the economic arguments, provide the strongest justification for building a WtE/CSP facility. Fort Bliss has the great fortune of having enormous potential for renewable energy production to include being one of very few installations that meet the economic criteria for WtE production.

In the past, one way to meet the mandates was to purchase RECs, but E.O. 13423 requires 50 percent of the renewable energy to be produced on federal property. Nevertheless, the price of RECs is used as a proxy to determine the value of meeting legislative mandates. RECs represent the environmental attributes of the power produced and can be sold separately from the electricity produced. Consumers purchase RECs either from their local utility or national markets. REC prices fluctuate depending on several factors such as volume purchased, region of generation, year of generation, and whether the REC purchase is for compliance or voluntary reasons. REC prices in Texas range from \$0.005 to \$0.030 per kWh. El Paso Electric offers RECs at \$0.0192 per kWh

(Department of Energy, 2010). REC purchase provides a good proxy to measure the value of meeting legislative mandates. The Excel analysis tool allows the decision maker to set a value for an REC and determine the percentage of electricity consumed to credit toward meeting legislative mandates. The baseline values are set to $0.0192 per kWh with the assumption that 100 percent of electricity consumed by Fort Bliss is renewable.

D. MEETING NET ZERO ENERGY GOALS BENEFITS

In order to meet the installation goal of becoming Net Zero Energy, Fort Bliss will need to produce as much electricity annually as it consumes above the 2003 baseline of 203,000 kWh of electricity (Toufic, 2010). While on-installation production of electricity above the baseline demand will meet the goal technically, a WtE/CSP facility can meet the installation's entire electricity demand, including the baseline demand. Becoming Net Zero Energy is a goal similar to achieving energy security. In order to monetize the benefit of meeting the Net Zero Energy goal, we compare it to the monetized values of energy security. The Excel analysis tool allows the decision maker to adjust the ratio evaluation of Net Zero Energy to energy security, but initially the ratio is arbitrarily set to 0.50. Sensitivity analysis in Chapter V Section B explores variations in this ratio. Sensitivity analysis also explores changes due to variations in the value of energy security dependent on PTC and the supply-surety-survivability relations.

V. RESULTS AND OBSERVATIONS

This chapter presents the calculations of the costs and benefits and sensitivity analyses. All factors except the emission reduction MTCO2E provided by the EPA's WARM can be adjusted within the Excel analysis tool. The resulting costs and benefits were first converted to millions of FY10 dollars and then summarized as a present value.

The inflation rate is set at 3 percent, but can be modified within the Excel analysis tool provided with this thesis. The Office of Management and Budget normally sets the discount rates, but in energy projects the Department of Energy sets the discount rate according to the Federal Energy Management Program (FEMP). FEMP currently has a minimum discount rate of 3 percent which is used in these calculations (Rushing, Kneifel, & Lippiatt, 2011). The discount rate can be adjusted within the Excel analysis tool as can the base year, currently set as 2010, and the project start year, currently set as 2015.

A. BASE CASE

The status quo for this thesis is no WtE/CSP facility being built. There are no benefits to calculate and the price of electricity remains at the status quo rate of $0.060 per kWh as provided by the Fort Bliss RFI. The projected electricity demands remain as seen earlier and the total net present value is a cost of $398 million (NPV FY10) over the same 20 year timespan of the proposed WtE/CSP case. This thesis may not have fully captured the status quo cost of electricity to the Fort Bliss installation. The blended rate of $0.060 appears low, but it remains the target rate and is close to the national industrial average. Other studies have used blended rates for Fort Bliss as high as $0.079 which may not include the savings from the Texas Military Preparedness Act of 2003 (Pacific Northwest National Laboratory, 2009).

B. WTE/CSP CASE

1. Sensitivity to Price of Electricity

As shown in Figure 5, seemingly small changes in the price of electricity make huge differences in the overall economics of a WtE/CSP case. An increase of $0.01, $0.02, or $0.03 per kWh results in a reduced overall net profit of $246, $179, and $113 million, respectively (NPV FY10) over the 20 year power purchase agreement.

Without accounting for any benefits, for every $0.01 increase in the price per kWh of electricity from the status quo rate to a WtE/CSP rate, we estimate that Fort Bliss pays an additional $66 million (FY10) over a 20 year power purchase agreement as shown by the negative amounts in the Electricity Savings bars in Figure 5. At the currently proposed $0.03 difference between WtE/CSP and status quo blended electricity rates, we estimate that Fort Bliss pays an additional $199 million (FY10) over a 20 year power purchase agreement. These numbers account for inflation and no benefit from any of the estimated benefiting factors. Annually, the loss begins at $11 million (FY10) in 2015 and slowly decreases to $7 million (FY10) in 2035. Figure 5 shows the total value of Electricity Savings and the Net Benefit to Fort Bliss which includes all benefits set at their default values over the 20 year power purchase agreement. The x-axis represents the difference in the price of electricity from a WtE/CSP rate varying from $0.070 to $0.105 per kWh and the status quo rate $0.060 per kWh. As you can see, the closer a WtE/CSP rate is to the status quo rate the more economically attractive a WtE/CSP project becomes. Any WtE/CSP rate above $0.105 per kWh is uneconomical even with the benefits included.

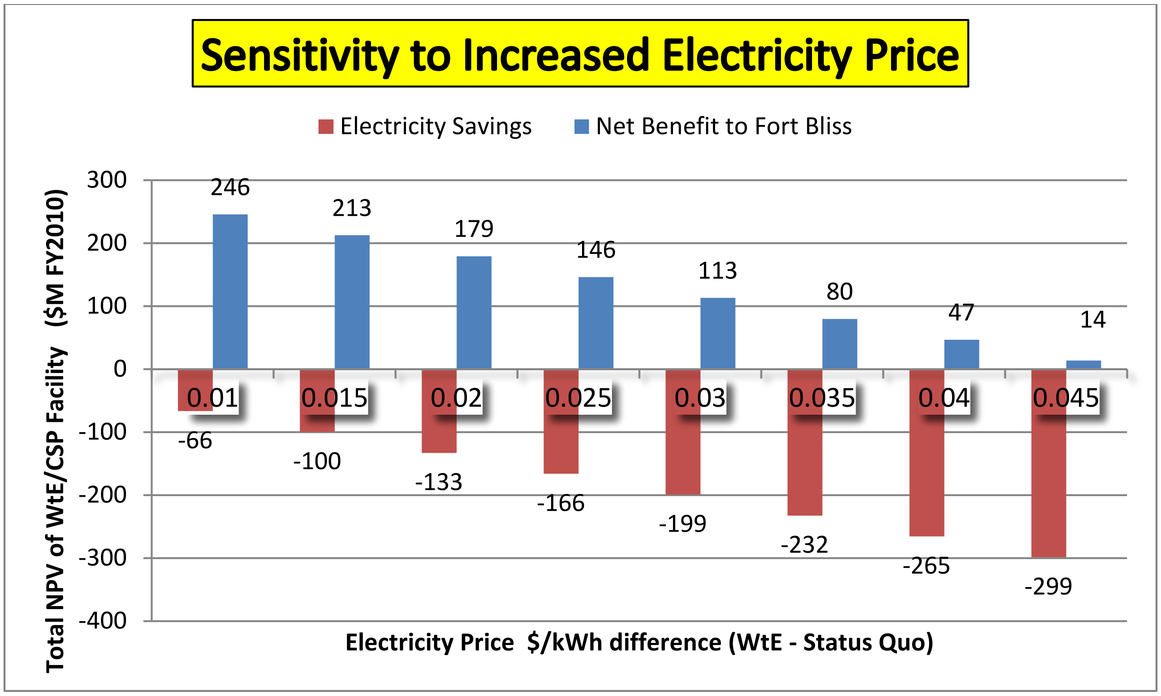

Figure 5. Sensitivity to differences in WtE/CSP vs. Status Quo electricity rates.

2. Sensitivity to Tipping Fee Price

Overall tipping fees count for a very small portion of the potential costs or benefits. Figure 6 shows the estimated costs or benefits based on differences between the landfill tipping fee and a WtE/CSP tipping fee. The x-axis varies from an eight dollar per ton decrease to a three dollar per ton increase in tipping fees. The default is that a WtE/CSP tipping fee will be seven dollars less than the landfill tipping fee. This default is based on a WtE tipping fee beginning at $19 per ton as specified in the Fort Bliss RFI and the landfill tipping fee beginning at $26 after complying with recent El Paso City ordinance as discussed in Chapter III Section C. As seen in Figure 6, using the historic annual increase of landfill tipping fees in the region adjusted for inflation, 1.68 percent, Fort Bliss has an estimated total savings of approximately $1.6 million (FY10) in waste disposal cost over the 20 year power purchase agreement. Assuming the landfill tipping fees would only increase with inflation results in a total of $1.0 million estimated savings for Fort Bliss. It is possible that in order to reduce the dollars per kWh electricity rate, a higher tipping fee would be charged, but the tipping fee is subject to contract

negotiations. A higher WtE/CSP tipping fee would actually benefit Fort Bliss since the installation accounts for less than two percent of waste disposal at a WtE/CSP facility.

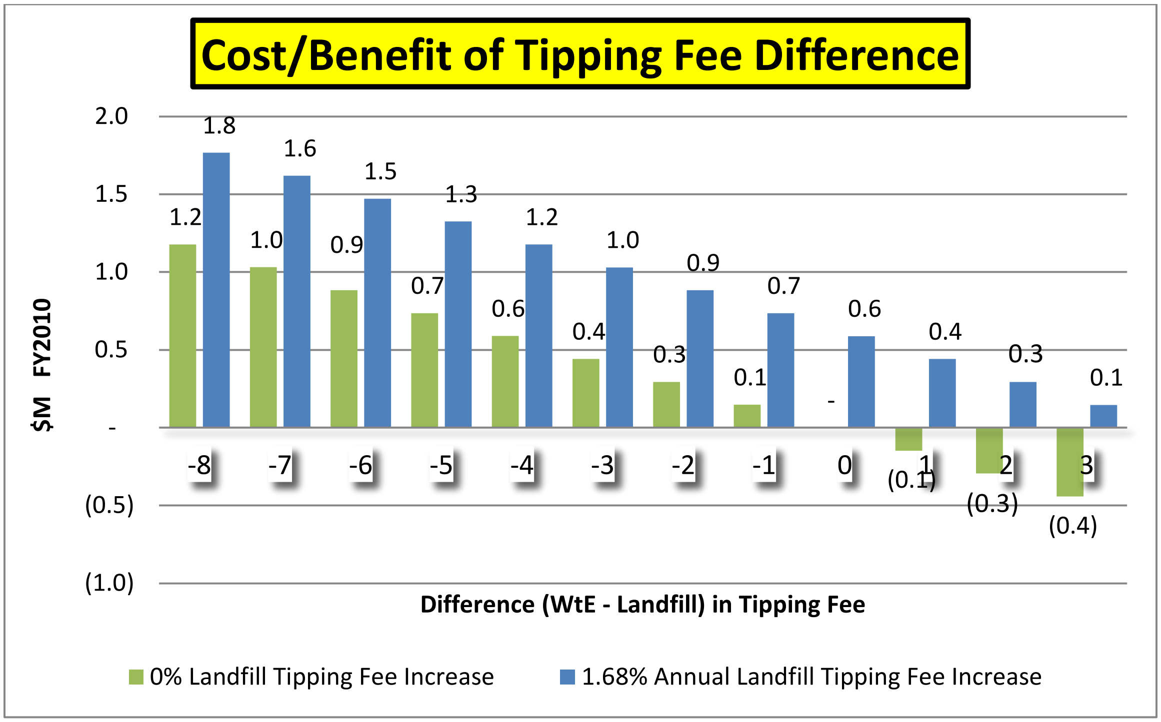

Figure 6. Cost/Benefit per dollar tipping fee changes (0% vs. 1.68% annual increase)

3. Sensitivity to Value of Emission Reductions

With increasing political and environmental pressures, the value per MTCO2E has potential to increase greatly during the term of the power purchase agreement. The current market value of the 264,025 tons MTCO2E emission reductions vary from $0.4 million to $21.7 million (FY10) over the 20 year power purchase agreement, based on $0.10 and $6.00 per MTCO2E respectively. Figure 7 shows potential monetary benefit up to $36.2 million based on a value of $10.00 per MTCO2E.

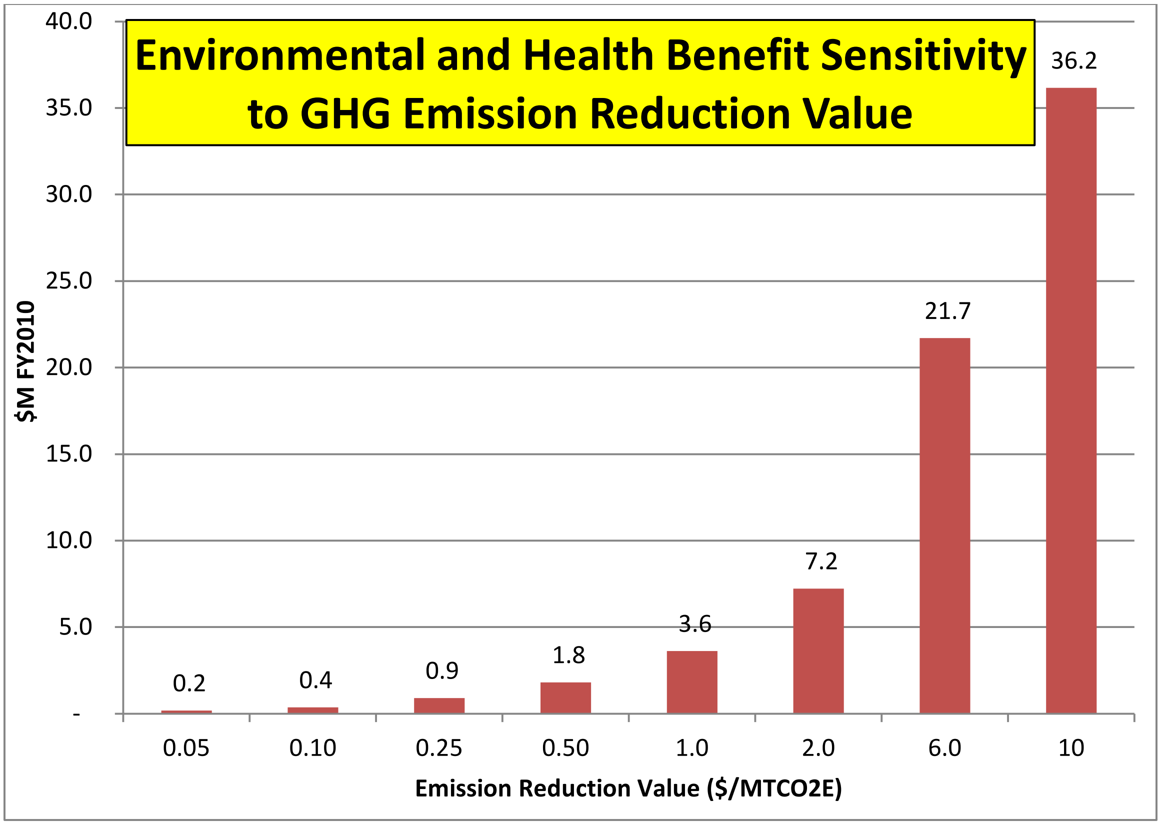

Figure 7. Environmental impact benefit sensitivity to $/MTCO2E

4. Sensitivity to Value of Energy Security

Since energy supply uses the federal renewable energy production tax credit as a proxy value and both energy surety and energy survivability are valued in relation to energy supply, the overall value of energy security fluctuates with the production tax credit value as seen in Figure 8 below. In this chart, the relations between supply, surety, and survivability play a small role in the overall values. The initial default relation portrays supply and surety as equal and survivability valued at half of supply. The middle bars portray all three of equal relative value. The final bars show the values with surety being twice the value of supply and survivability being of equal value. The default relation along with the default production tax credit price of $0.011 gives a benefit of $122 million (FY10) over the 20 year power purchase agreement.

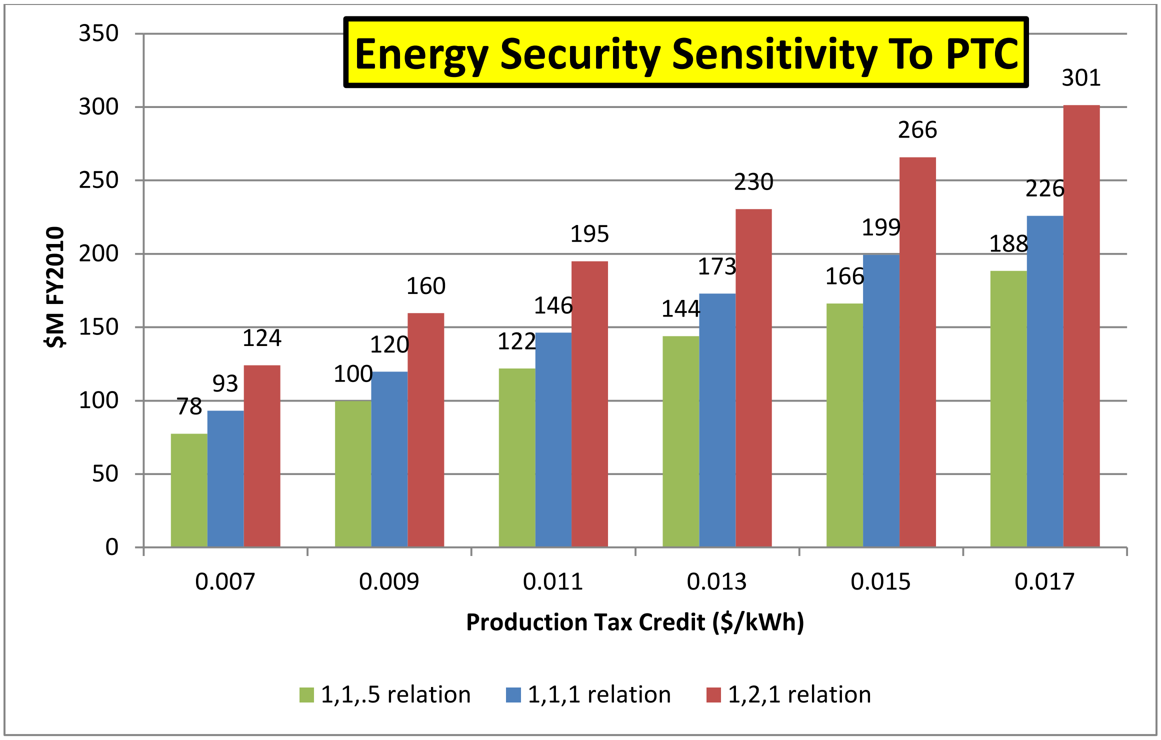

Figure 8. Energy security sensitivity to PTC at varying supply-surety-survivability relations

5. Sensitivity to Value of Meeting Legislative Mandates

Meeting legislative mandates represents one of the largest driving forces in most renewable energy projects across the Army. A Fort Bliss WtE/CSP facility would potentially provide a great deal of the renewable energy toward those mandates. The Excel analysis tool allows the decision maker to determine the percentage of electricity consumed from a WtE/CSP facility by Fort Bliss credited as a benefit to the project. The tool also allows the decision maker to determine the price of the REC which fluctuates greatly. The graph in Figure 9 shows 25 percent consumption versus the 100 percent consumption credited to the project and varies based on the dollars per kWh REC price along the x-axis. The value for meeting legislative mandates fluctuates from $8 million to $232 million (FY10) over the 20 year power purchase agreement. The default REC price of $0.0192 per kWh represents the REC price available from El Paso Electric (Department of Energy, 2010). The default percentage of 100 percent represents all of the electricity consumed by Fort Bliss from a WtE/CSP facility because the 25 percent by

2025 mandate applies Army-wide not installation by installation. At these defaults the value of meeting legislative mandates becomes $127 million (FY10) over the 20 year power purchase agreement.

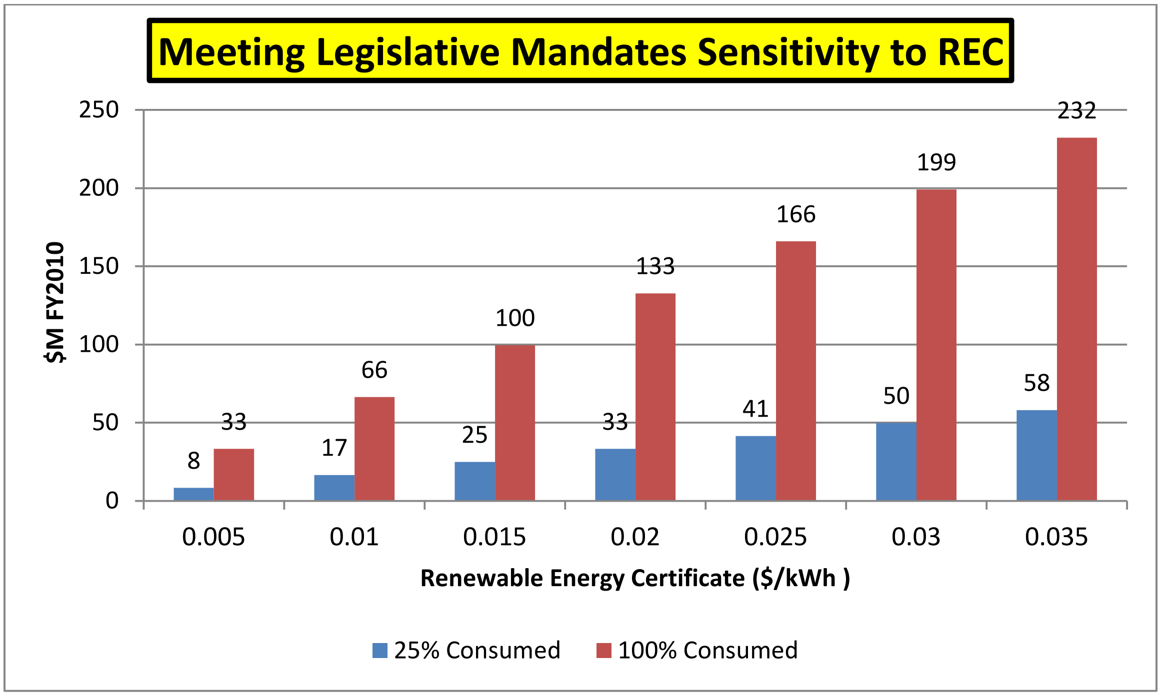

Figure 9. Meeting legislative mandates value based on REC price and percent consumed credited

6. Sensitivity to Value of Meeting Net Zero Energy Goals

The sensitivity of the monetary value of meeting Net Zero Energy goals depends on both the value given to it compared to energy security and the value of energy security. To capture the sensitivity of the value given to it compared to energy security, the value of energy security remains constant as the values assigned to meeting Net Zero Energy goals vary. In Figure 10, the value of energy security is set at its default value of $122 million (FY10) and the values of meeting Net Zero Energy goals vary from 0.10 and 2. This causes the value of meeting Net Zero Energy goals to vary from $12 million and $244 million (FY10) over the 20 year power purchase agreement. Using the default setting of 0.50 the value of meeting Net Zero Energy goals becomes $61 million (FY10).

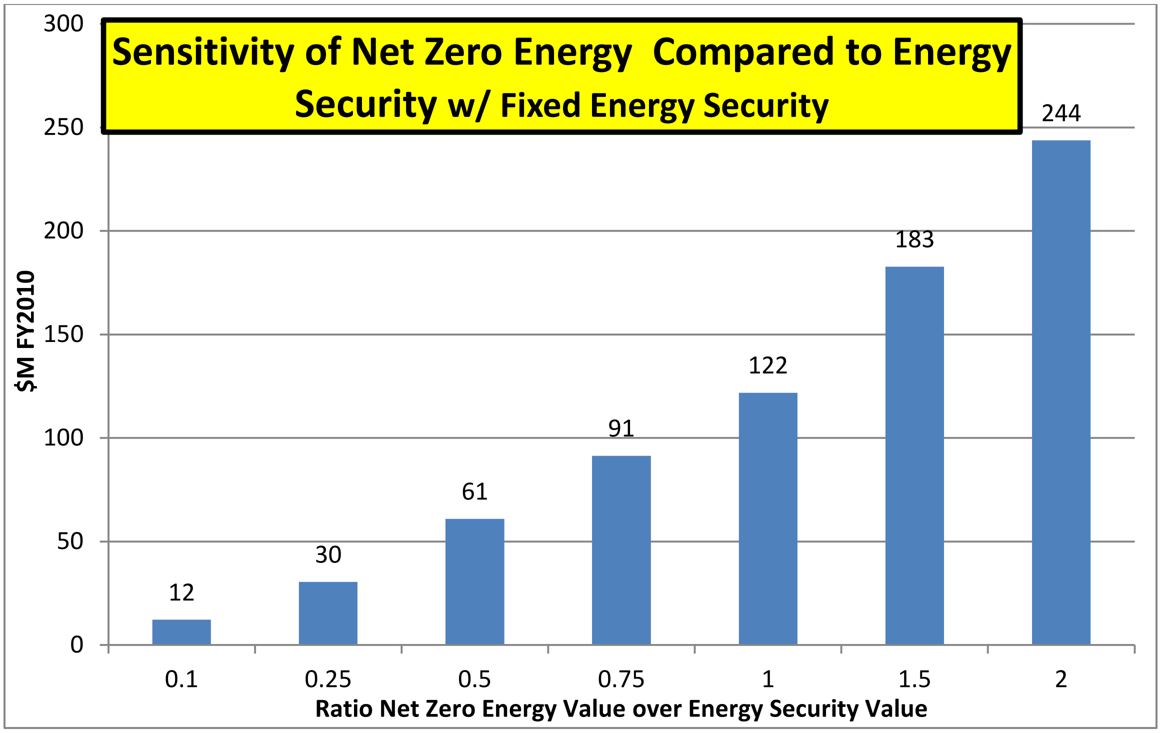

Figure 10. Meeting Net Zero Energy goal value compared to energy security value

To capture the sensitivity of the value of meeting Net Zero Energy goals relative to variations in energy security values, the comparable value of meeting Net Zero Energy goals to energy security is set at the default of 0.50 while energy security values vary as they did in the energy security sensitivity analysis seen earlier. Seen in Figure 11, these values vary as a result to the changes in value of energy security. Energy security values vary based on the renewable energy production tax credits along the x-axis and the comparative relations of supply, surety, and survivability. The meeting Net Zero Energy goals vary from $39 million on the low end to $151 million (FY10) on the high end over the 20 year power purchase agreement.

.

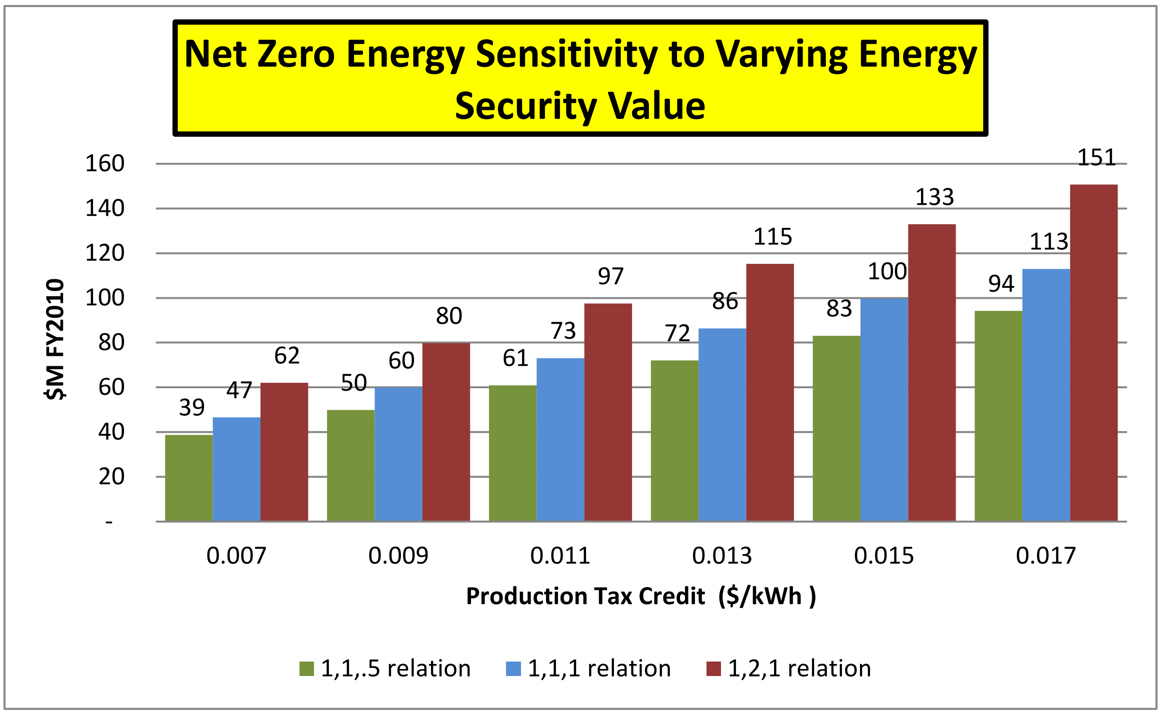

Figure 11. Net Zero Energy goal value with varying energy security PTC and relation values

THIS PAGE INTENTIONALLY LEFT BLANK

VI. CONCLUSION

Based solely on the economics of higher electricity rates, a Fort Bliss WtE/CSP hybrid power facility represents a poor business decision by the Army compared to the base case because of the increased cost of electricity from such a facility.

Based on the existing Legislative mandates, a Fort Bliss WtE/CSP hybrid power facility represents a good business decision by the Army because the facility provides a large percentage of the required electricity from renewable sources. A WtE/CSP facility single-handedly produces enough electricity to meet the entire installation's annual demand well into the future.

A. RECOMMENDED FUTURE STUDY

A health benefit not covered in this thesis includes the prevention of landfill leachate contaminating local landfills. Federal law requires modern landfills to have liners to prevent leachate contamination, but many residents near landfills still have concerns about leachate contamination of underground drinking water supplies. An attempt to monetize this prevention would be challenging since the relationship between uncommon illnesses and landfill leachates is very difficult to link. More research into landfill leachate illness prevention may result in a monetized value for this health benefit along the lines of community appreciation for not having landfills nearby.

Monetizing energy surety independent of energy supply would benefit future analysis of energy security. One path would be to first monetize energy sufficiency, then adjust the electrical demands of critical missions to the electrical demand of the entire installation. Once the large increases to facilities on Fort Bliss are complete and all critical missions are identified, an electrical demand of those critical missions could be accomplished through analysis of the electrical metering system. The critical demand data would not be easily retrievable and could require a classified thesis. The electrical metering data would probably require thesis travel to Fort Bliss.

Other benefits not explored in this thesis that may have an effect on the value of renewable energy projects to Fort Bliss or other military installations include the financial

benefit of the creation of green jobs, the financial benefit of potential carbon tax cost avoidance, the financial benefit of meeting Net Zero Waste goal, and the benefits of contributing to Texas' Renewable Portfolio Standard.

Costs not explored are potential negative environmental or health impacts attributable to a WtE/CSP facility. These benefits and impacts are extremely difficult to clarify and much harder to monetize. Another cost not explored is the cost of the land for a WtE/CSP facility. Given the current push to utilize federal lands for renewable energy projects and the unknown exact location of a WtE/CSP facility, this cost may be negligible.

A future business case study may analyze the possibility that El Paso Electric or the City of El Paso buy all of the 664,000 MWh of electricity from a WtE/CSP facility under a PPA at $0.090 per kWh and sell a certain amount to Fort Bliss at their current electricity rate while selling the rest to residents under the residential rate. A study objective would be to find the amount of renewable energy that could be sold to Fort Bliss at $0.060 and still be profitable for the PPA buyer. A REC premium may or may not be charge to the resident in the analysis.

APPENDIX A: WASTE REDUCTION MODEL METHODOLOGY AND INPUTS

The U.S. Environmental Protection Agency's (EPA) Waste Reduction Model (WARM) is an Excel tool created to assist solid waste management decisions based on greenhouse gas (GHG) emissions and energy usage considerations. WARM allows decision-makers to compare the life-cycle greenhouse gas emissions and energy usage for end-of-life material management. WARM's five waste management options are recycling, reduction, landfilling, waste to energy (WtE), and composting. WARM compares a baseline, in our case landfilling, to an alternative method, in our case WtE, and provides the greenhouse gas emission changes and the energy usage changes between the waste management options. WARM uses a waste generation reference point rather than raw materials extraction reference point to calculate the greenhouse gas emission changes because WARM is waste management focused. EPA has collected greenhouse gas emission information on thousands of materials over the years and updates WARM periodically.   This thesis uses version 12 release in February 2012 (U.S. EPA, 2012).

WARM allows the user to input the tonnage and type of materials to use in the waste management options. For this thesis, we used the overall tonnage required by a Fort Bliss WtE/CSP facility, 1 million tons. The types of material are estimated based on typical municipal solid waste content (WorleyParsons, 2011), commercial waste content (CA EPA, 2009), and construction waste content (U.S. EPA, 1998). As shown in Figure 12, the estimated tonnage of waste by material type is entered into the baseline waste management option, landfilling, and the alternate option, combustion.

Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Tons Generated	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans				NA	0.0				-	NA
Aluminum Ingot				NA	0.0				-	NA
Steel Cans				NA	0.0				-	NA
Copper Wire				NA	0.0				-	NA
Glass		25,920		NA	25920.0				25,920	NA
HDPE				NA	0.0					NA
LDPE	NA			NA	0.0		NA			NA
PET				NA	0.0					NA
LLDPE	NA			NA	0.0		NA			NA
PP	NA			NA	0.0		NA			NA
PS	NA			NA	0.0		NA			NA
PVC	NA			NA	0.0		NA			NA
PLA	NA				0.0		NA			
Corrugated Containers				NA	0.0					NA
Magazines/Third-class Mail				NA	0.0					NA
Newspaper				NA	0.0					NA
Office Paper				NA	0.0					NA
Phonebooks				NA	0.0					NA
Textbooks				NA	0.0					NA
Dimensional Lumber				NA	0.0					NA
Medium-density Fiberboard				NA	0.0					NA
Food Scraps	NA	38,500			38500.0		NA		38,500	
Yard Trimmings	NA	42,000			42000.0		NA		42,000	
Grass	NA				0.0		NA			
Leaves	NA				0.0		NA			
Branches	NA	20,000			20000.0		NA		20,000	
Mixed Paper (general)		210,870		NA	210870.0	NA			210,870	NA
Mixed Paper (primarily residential)				NA	0.0	NA				NA
Mixed Paper (primarily from offices)				NA	0.0	NA				NA
Mixed Metals		50,250		NA	50250.0	NA			50,250	NA
Mixed Plastics		88,630		NA	88630.0	NA			88,630	NA
Mixed Recyclables				NA	0.0	NA				NA
Mixed Organics	NA	124,640			124640.0	NA	NA		124,640	
Mixed MSW	NA	167,330		NA	167330.0	NA	NA		167,330	NA
Carpet		24,500		NA	24500.0				24,500	NA
Personal Computers		20,500		NA	20500.0				20,500	NA
Clay Bricks	NA	11,400	NA	NA	11400.0		NA	11,400	NA	NA
Concrete [1]			NA	NA	0.0	NA			NA	NA
Fly Ash [2]			NA	NA	0.0	NA			NA	NA
Tires [3]				NA	0.0					NA
Asphalt Concrete			NA	NA	0.0				NA	NA
Asphalt Shingles		11,400		NA	11400.0				11,400	NA
Drywall		51,300	NA	NA	51300.0			51,300	NA	NA
Fiberglass Insulation	NA		NA	NA	0.0		NA		NA	NA
Vinyl Flooring	NA			NA	0.0		NA			NA
Wood Flooring	NA			NA	0.0		NA			NA

Figure 12. Estimated waste tonnage by type entered into the EPA WARM

Figure 13 shows the nine additional inputs into the WARM calculations and the selections used for this thesis. The state and region are chosen in question 3. Question 4 applies to the waste management option source reduction not used in this thesis. Question 5a requests information about landfill gas control systems. The national average is used for this thesis. Question 5b asks about landfill gas recovery methods. In 2008, a large landfill that serves the Fort Bliss area began converting its landfill gas into energy so the recover-for-energy option is used (U.S. EPA, 2012). Question 6a refers to the moisture conditions of the municipal solid waste in the landfill. The default selection is used. Question 6b refers to the efficiency of the landfill gas collection system. Again, the default setting is used. Question 7a asks about the distances traveled by municipal solid waste collection vehicles. Since the final location of a WtE/CSP facility is unknown, the default setting is used. Question 7b is a follow up data entry point for question 7a.

3. In order to account for the avoided electricity-related emissions in the landfilling and combustion pathways, EPA assigns the appropriate regional "marginal" electricity grid mix emission factor based on
Select state for which you are conducting this analysis.

Please select state or select national average:	Texas
Region Location:	West South Central

4. To estimate the benefits from source reduction, EPA usually assumes that the material that is source reduced would have been manufactured from the current mix of virgin and recycled inputs. However, you may choose to estimate the emission reductions from source reduction under the assumption that the material would have been manufactured from 100% virgin inputs in order to obtain an bound estimate of the benefits from source reduction. Select which assumption you want to use in the analysis. Note that for materials for which information on the share of recycled inputs used in prod or is not a common practice; EPA assumes that the current mix is comprised of 100% virgin inputs. Consequently, the source reduction benefits of both the "Current mix" and "100% virgin" inputs are the

- (•) Current Mix
- ( ) 100% Virgin

5a The emissions from landfilling depends on whether the landfill where your waste is disposed has a landfill gas (LFG) control system. If you do not know whether your landfill has LFG control, select "National Average" to calculate emissions based on the estimated proportions of landfills with LFG control in 2009 and go to question 7. If your landfill does not have a LFG system, select "No LFG Recovery" and go to question 7. If a LFG system is in place at your landfill, select "LFG Recovery" and click one of the indented buttons in 5b to indicate whether LFG is recovered for en

- (•) National Average
- ( ) LFG Recovery
- ( ) No LFG Recovery

5b If your landfill has gas recovery, does it recover the methane for energy or flare it?

- (•) Recover for energy
- ( ) Flare
- ( ) Not Applicable

6a Which of the following moisture conditions and associated bulk MSW decay rate (k) most accurately describes the average conditions at the landfill?
The decay rates, also referred to as k values, describe the rate of change per year (yr-1) for the decomposition of organic waste in landfills. A higher average decay rate means that waste decomposes f Dry landfills typically receive less than 25 inches of rain annually while Average landfills receive more than 25 inches of rain annually. Wet landfills are assumed to represent a landfill that receives relati high water infiltration. Bioreactor landfills include landfills to which water is added until the moisture content reaches 40 percent moisture on a wet weight basis.

- ( ) Dry (k=0.02)
- (•) Average (k = 0.04) - DEFAULT
- ( ) Wet (k = 0.08)
- ( ) Bioreactor (k = 0.12)

6b For landfills that recover landfill gas, the landfill gas collection efficiency will vary throughout the life of the landfill. Based on literature and field study measurements for different landfill scenarios, the typical operation landfills represent the current practice at most landfills that capture landfill gas in the United States. The worst-cast collection represent landfills that are just barely in compliance with EPA's New Source Performance Standards (NSPS). The aggressive gas collection best-case recovery scenario for bioreactor landfills, where conditions are controlled in order to achieve decomposition as quickly as possible and to collect gas aggressively.

- (•) Typical operation - DEFAULT
- ( ) Worst-case collection
- ( ) Aggressive gas collection

	Landfill gas collection efficiency (%) assumptions
Typical	*Years 0-2: 0%; Year 3: 50%; Year 4-7: 75%; Years 8-100: 95%*
Worst-case	*Years 0-5: 0%; Years 6-7: 75%; Years 8-100: 95%*
Aggressive	*Year 1: 25%; Years 2-3: 50%; Years 4-7: 75%; Years 8-100: 95%*

7a Emissions that occur during transport of materials to the management facility are included in this model. You may use default transport distances, indicated in the table below, or provide information on transport distances for the various MSW management options.

- (•) Use Default Distances
- ( ) Provide Information

7b If you have chosen to provide information, please fill in the table below. Distances should be from the curb to the landfill, combustor, or material recovery facility (MRF).
*Please note that if you chose to provide information, you must provide distances for both the baseline and the alternative scenarios.

Management Option	Default Distance	Distance (Miles)
Landfill	20	
Combustion	20	
Recycling	20	
Composting	20	

Figure 13. Setting used in the EPA WARM to predict GHG emission reductions

THIS PAGE INTENTIONALLY LEFT BLANK

LIST OF REFERENCES

Army Senior Energy Council. (2009, January 13). *Army Energy Security Implementation Strategy*. Retrieved May 31, 2012, from Assistant Secretary of the Army For Installations, Energy and Environment: http://www.asaie.army.mil/Public/Partnerships/EnergySecurity/

Assistant Secretary of the Army (IE&E). (2010, April 1). *Energy Security: Army Priority and National Imperative*. Retrieved April 18, 2012, from Assistant Secretary of the Army For Installations, Energy and Environment. http://www.asaie.army.mil/Public/Partnerships/EnergySecurity/

Bond University. (2012, March 1). *Carbon Market Integrity: A Review of the Australian Carbon Market Mechanism.* Retrieved June 1, 2012, from Carbon Market Institute: http://www.carbonmarketinstitute.org/publications

Bureau of Labor Statistics. (2012, April 23). *Database, Tables & Calculators by Subject*. Retrieved April 23, 2012, from Bureau of Labor Statistics Data: http://data.bls.gov/pdq/SurveyOutputServlet

CA EPA. (2009, August 1). *California 2008 Statewide Waste Characterization Study.* Retrieved April 18, 2012, from California Environmental Protection Agency: http://www.calrecycle.ca.gov/Publications/General/2009023.pdf

Defense Science Board. (2008, February 1). *DOD Energy Strategy "More Fight - Less Fuel".* Retrieved April 18, 2012, from Under Secretary of Defense For Acquisition, Technology and Logistics: http://www.acq.osd.mil/dsb/reports/ADA477619.pdf

Department of Defense. (2010, January 29). *Greenhouse Gas Targets Announcement for DOD.* Retrieved April 25, 2012, from Defense News Release: http://www.defense.gov/Release/Release.aspx?ReleaseID=13276

Department of Energy. (2008, January 28). *Renewable Energy Requirement Guidance for EPACT 2005 and Executive Order 13423.* Retrieved May 2, 2012, from Energy Efficiency and Renewable Energy Federal Energy Management Program: http://www1.eere.energy.gov/femp/pdfs/epact05_fedrenewenergyguid.pdf

Department of Energy. (2010, December 1). *The Green Power Network*. Retrieved May 2, 2012, from Energy Efficiency & Renewable Energy: http://apps3.eere.energy.gov/greenpower/buying/buying_power.shtml?state=TX

Department of the Army. (2012, February 8). *Environmental Impact Statement for the Implementation of Energy, Water, and Solid Waste Sustainability Initiatives at Fort Bliss, TX*. Retrieved May 13, 2012, from Federal Register: https://federalregister.gov/a/2012-2844

Deputy Under Secretary of Defense (I&E). (2011). *DOD Annual Energy Management Report FY2010*. Retrieved May 2, 2012, from Deputy Under Secretary of Defense For Installations and Environment: http://www.acq.osd.mil/ie/energy/energymgmt_report/main.shtml

DSIRE. (2011, June 3). *Federal Incentives/Policies for Renewables & Efficiency*. Retrieved April 15, 2012, from Database of State Incentives for Renewables & Efficiency: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code

Environmental Leader. (2011, October 11). *BofA Merrill Enters California Carbon Market*. Retrieved June 1, 2012, from Environmental Leader: http://www.environmentalleader.com/2011/10/11/bofa-merrill-enters-california-carbon-market/

Fox News. (2011, September 9). *Power Back for Millions in California, Arizona, and Mexico*. Retrieved May 22, 2012, from FoxNews.com: http://www.foxnews.comhttp://www.foxnews.com/us/2011/09/08/power-outage-affects-millions-in-california-arizona-and-mexico

Garcia, M. (2010, August 24). *El Paso To Take Over Disposal Of Commercial Waste In City*. Retrieved April 3, 2012, from kvia.com: http://www.kvia.com/news/24747057/detail.htm

Guiney, B. (2011, November 23). *Fort Bliss: Ground-Zero for Net Zero*. Retrieved December 15, 2011, from Center For A Better Life: http://www.centerforabetterlife.com/eng/magazine/article_detail.lasso?id=234

Jacobi, J. (2011, June 1). Waste to Energy Technology. Atlanta, GA, USA: ScottMadden.

KTSM News. (2009, March 2). *Power Outage Affects 100000 People*. Retrieved April 9, 2012, from Newschannel 9: http://www.ktsm.com/news/power-outage-affects-100000-people

KTSM News. (2011a, June 6). *163000 Lost Power in El Paso*. Retrieved April 9, 2012, from Newschannel 9: http://www.ktsm.com/news/163000-lost-power-in-el-paso

KTSM News. (2011b, June 27). *Northeast El Paso Power Outage*. Retrieved April 9, 2012, from Newschannel 9: http://www.ktsm.com/news/northeast-el-paso-power-outage

KTSM News. (2011c, June 13). *Power Outage in NE El Paso*. Retrieved April 9, 2012, from Newschannel 9: http://www.ktsm.com/news/power-outage-in-ne-el-paso

Lopez, C. (2011, November 4). *Army Summit Attracts Potential Energy Investors*. Retrieved April 3, 2012, from Army.mil: http://www.army.mil/article/68800/Army_summit_attracts_potential_energy_investors/

McCarthy, T. (2011, October 12). *RFI - Net Zero Energy Fort Bliss*. Hampton, NH, USA: Wheelabrator Technologies Inc.

Obama, B. (2012, January 24). *State of the Union 2012.* Retrieved January 26, 2012, from Washington Post: http://www.washingtonpost.com/politics/state-of-the-union-2012-obama-speech

Pacific Northwest National Laboratory. (2009). *Renewable Energy Opportunities at Fort Bliss, Texas.* Washington DC: U.S. Department of Energy.

Peters-Stanley, M., Hamilton, K., Marcello, T., & Sjardin, M. (2011, June 2). *Back to the Future: State of the Voluntary Carbon Markets 2011.* Retrieved April 3, 2012, from Ecosystem Marketplace: http://www.forest-trends.org/documents/files/doc_2829.pdf

Repa, E. (2006, January 1). *NSWMA's 2005 Tip Fee Survey.* Retrieved April 3, 2012, from Evironmentalists Every Day: http://www.environmentalistseveryday.org/docs/Tipping-Fee-Bulletin-2005.pdf

Repa, E. (2011, October 1). *Municipal Solid Waste Landfill Facts*. Retrieved April 3, 2012, from National Solid Wastes Management Association: http://www.environmentalistseveryday.org/docs/research-bulletin/Municipal-Solid-Waste-Landfill-Facts.pdf

Rushing, A., Kneifel, J., & Lippiatt, B. (2011). *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis.* Retrieved May 2, 2012, from Department of Energy: http://www1.eere.energy.gov/femp/pdfs/ashb10.pdf

SAS Institute, Inc. (2009). *JMP 8 Statistics and Graphics Guide, Second Edition.* Cary, NC: SAS Institute, Inc.

Schladen, M. (2010a, September 30). *El Paso Electric customers subsidizing Fort Bliss' electric bill*. Retrieved April 3, 2012, from El Paso Times.com: http://www.elpasotimes.com/news/ci_16208610

Schladen, M. (2010b, August 11). *El Paso Turns Down Landfill Contract*. Retrieved April 15, 2012, from The Scrappy Pages: http://www.thescrappypages.com/blog/el_paso_turns_down_landfill_contract

Tomlinson, B. (2011a). *Fort Bliss, TX - Fact Sheet.* Fort Bliss: Fort Bliss Garrison DPW.

Tomlinson, B. (2011b, July 23). RFI WtE/CSP Facility. *RFI Utililty Scale Waste-to-Energy, Concentrating Solar Power Hybrid Facility*. Fort Bliss, TX, USA: Fort Bliss Directorate of Public Works.

Toufic, A. (2010, August 15). *Fort Bliss Renewable Energy Program.* Retrieved April 18, 2012, from GovEnergy: http://www.govenergy.com/2010/Workshop/Presentations.aspx

U.S. Census Bureau. (2012, January 31). *El Paso, Texas*. Retrieved April 9, 2012, from State & County Quickfacts: http://quickfacts.census.gov/qfd/states/48/4824000.html

U.S. EIA. (2012, April 30). *Electricity*. Retrieved May 23, 2012, from Energy Information Administration: http://www.eia.gov/electricity

U.S. EPA. (1998, June 1). *Characterization of Building-Related Construction and Demolition Debris in the United States.* Retrieved April 18, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/epawaste/hazard/generation/sqg/cd-rpt.pdf

U.S. EPA. (2011a, August 16). *Greening EPA - Executive Order 13514*. Retrieved April 25, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/greeningepa/practices/eo13514.htm

U.S. EPA. (2011b, April 6). *Public Health, Safety, and the Environment*. Retrieved April 3, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/lmop/faq/public.html

U.S. EPA. (2011c, December 1). *Waste - Non-Hazardous Waste - Municipal Solid Waste.* Retrieved April 3, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/osw/nonhaz/municipal/msw99.htm

U.S. EPA. (2012, February 29). *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM).* Retrieved May 30, 2012, from U.S. Environmental Protection Agency: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Waste Permits Division. (2006, June 1). *Municipal Solid Waste in Texas*. Retrieved April 15, 2012, from Texas Commission on Environmental Quality: http://www.tceq.state.tx.us/publications

WorleyParsons. (2011). *Analysis of Hybrid Concentrating Solar Power (CSP)/Waste-to-Energy (WtE) Plant with Common Power Block.* Golden: National Renewable Energy Laboratory.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center
   Ft. Belvoir, Virginia

2. Dudley Knox Library
   Naval Postgraduate School
   Monterey, California